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## British Industrial Policy Concerning the Heavy Ordnance Industry, 1900–1917

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**British Industrial Policy Concerning the Heavy Ordnance Industry,  
1900-1917**

**A Thesis Presented in Fulfilment for the Degree  
DOCTOR OF PHILOSOPHY  
In the Subject of  
WAR STUDIES**

**By  
Andrew Breer**

**King's College, London  
University of London  
September 2015  
Word Count: 99,865**

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## **ABSTRACT**

This thesis analyses the complex relationship between the arms industry and the British Government from 1900–1917. How did the British Civil Service convey strategic industrial policy in peacetime and what was its effectiveness in wartime through ordnance contracts and Westminster policy? The methodology follows a chronological analysis of both Governmental and industry documentation to see both sides holistically, through demand and supply, of a high-grade, non-commodity, durable good: artillery tubes. This thesis will utilize previously secret and unpublished records from both the Royal Navy and British Army procurement programmes to analyse the underpinnings of peacetime supply and wartime demand, institutional and personal relationships, industrial capacity, the effects of wartime shock under the Admiralty and War Office, and the creation and effectiveness of the Ministry of Munitions under future Prime Minister David Lloyd George and others.

## **ACKNOWLEDGMENTS**

I would like to thank Professor Brian Holden Reid for his work as the primary supervisor on this thesis. I would also like to thank Professor Frank Cooling of the Industrial College of the Armed Forces, Washington, DC, for being instrumental from the conception of this thesis. I was given generous funding from the Jackson-Hope Foundation of the Virginia Military Institute. I would like to acknowledge the help and support of Professor David Stevenson, LSE; Dr Graham Honeyman, Sheffield Forgemasters; Professor Nicholas Rodger, All Souls, Oxford; Dr Alan James, KCL; Professor Andrew Lambert, KCL; Professor Bill Philpott, KCL; Professor David Edgerton, KCL; Professor David French, UCL; Dr Ian Buxton, University of Newcastle; Dr Brian Newman, University of Newcastle; Mr Claude Crump, United States Coast Guard; Col. Keith Gibson, Virginia Military Institute; Col. Bruce Vandervort, Virginia Military Institute; Col. Malcolm Muir, Virginia Military Institute; Col. Tom Davis, Virginia Military Institute; Mr Alex Wilson, KCL; Mr Chris Newton, KCL; Dr Richard Dunley, The National Archives; Mr Luke Mercaldo; the late Mr Tony Edwards; Vice Admiral Jeremy Blackham, RN, Ret; Professor Alan Gropman, ICAF; Mr Len Barnett; Dr Simon House; Dr Tony Cowan, KCL; Mr Andrew Choong, Plans and

Photographs Department, National Maritime Museum, Woolwich and  
Mrs Elizabeth Cartmell for granting access to the papers of her grandfather  
Sir Charles Harris.

## **GLOSSARY OF ACRONYMS AND ABBREVIATIONS**

BA	British Army
B.L	Breech Loading
CY	Calendar Year
Calibre	The length of the barrel as a ratio to the projectile diameter
CSOF	Chief Superintendent of Ordnance Factories
DNO	Director of Naval Ordnance
Cwt.	Hundredweight, 112 pounds
EOC	Elswick Ordnance Company (Also known as Armstrong Whitworth)
F/S	Feet per second (measurement of velocity)
FY	Fiscal Year
GHQ	General Headquarters
HM	Her/His Majesty's
Lb.	Pound (unit of weight)
MGO	Master General of Ordnance
M.L	Muzzle Loading
MV	Muzzle Velocity
PRO	Public Records Office (superseded by TNA)
Pr.	Pounder, a measure of the size of the artillery projectile
Pence	in Pre-decimalization, 12 Pence made a Shilling
Q.F	Quick-firing, ammunition and powder together
P&E	Proof and Evaluation
RCF	Royal Carriage Factory, Woolwich
RGF	Royal Gun Factory, Woolwich
RN	Royal Navy
Shilling	in Pre-decimalization, 20 Shillings made a Pound
TNA	The National Archives of the United Kingdom
VM	Vickers Maxim



MAP 1. BRITISH INDUSTRIAL AND POLITICAL LOCATIONS,



## **CHAPTER ONE: INTRODUCTION**

My original contribution to knowledge is an analysis of British industrial orders and output for artillery tubes, from the perspective of the British Government from 1900 to 1917. Artillery were defined as the hollow cylinders that either on their own or in conjunction with other tubes, made artillery barrels. All previous studies of British ordnance in the period under analysis were written from the point of view of private owned industry, mainly the companies Vickers and Armstrong. This thesis utilizes British governmental sources to analyse the role of both the Government and the Trade. This perspective has never before been analysed and reveals a different understanding and also comes to different conclusions as to the effectiveness of the efforts of the British Government as a whole and of the arms industry in particular. Much of the research in this thesis runs counter to existing historiography, primarily due to the availability of new sources by this author. Due to the secret and technical nature of the documents, they were not released until more than 50 years had passed after the end of the First World War. The Ministry of Defence, the successor of the departments studied, began to release the documents through The National Archives beginning in the mid-1970s through the 1990s. As the canon of secondary literature was written before this point of

release, it is understandable that previous authors came to different conclusions based upon the information available to them at the time of their research and publication.

This thesis analyses how Britain equipped its armed forces from 1900 to 1917. The two dates were chosen for specific reasons. 1900 began a period of intense study of ordnance and the lessons learned from the Boer War. 1917 represents the end of First World War for new work on British gun contracts. After April 1917, American requirements for creating an American Expeditionary Force took over excess British and American industrial capacity, and British numbers of guns remained relatively static until the Armistice was signed in November 1918. As will be demonstrated, the majority of orders for ordnance were placed in 1914 and early 1915 with deliveries into the summer of 1916. After that point, contracts were scarce for most ordnance except the larger, and less numerous, heavy guns. As capacity had been created by then, little can be learned about industrial policy by looking at events later than mid-1917.

This thesis takes a narrow view of the subjects studied. It only discusses artillery from the 13-pr. and larger through to the 15-inch super-*Dreadnought* battleship guns. Importantly, the thesis examines the production of ordnance from the contemporary perspective of both the Royal Navy and British Army. In modern parlance, this thesis looks at

issues of ordnance from the 'joint' perspective. This thesis does not deal with other ordnance such as small arms, trench mortars, guns lighter than the 13-pr, guns above 15-inch, naval mountings, gun carriages, propellants, shells, or other expendables. It also does not discuss anti-aircraft and anti-dirigible guns. As well, this thesis is about the strategic decisions and policies enacted by the Government and its uniformed officers and civil servants. This is not a thesis focusing on the supply side of production, except in places where it is critical to understanding governmental policies. As well, this thesis does not discuss operational uses of artillery, ending its interest in guns once they are proofed and accepted by the services, unless use affects the actual industrial, manufacturing, and business of procuring weapons. The use of weapons, including tactics and operational history, is simply outside the scope of this thesis, and there is already an extensive historiography on the use of ordnance for both services.

No matter the period in time, navies and armies cannot fight wars or defend the peace without being armed. Acquisition and procurement is the most overlooked and understudied sector of the wheel that drives the sovereign ability to conduct war. It is certainly the case for historians of the First World War that not only industry, but also the State's ability to leverage production in industrial warfare has largely been misunderstood or unmentioned in the historiography as a whole.

This thesis illuminates British strategic industrial policy from 1900–1917 and its strategic effects both intentional and unintentional. Artillery production as a microcosm allows several specific analysis benefits, including a constant group of government and industry players before, during, and after the conflict due to the inherent high costs of entry into production. The subject also allows an analysis of public/private production of similar goods. The period selected also allows the second chapter to discuss the pre-war policies set by Parliament from the start of the cordite era at the turn of the century to full scale mobilization. At the other end, by the conclusion of 1917, ordnance contracts placed in 1914 and 1915 in the United Kingdom and the United States were being fulfilled and the forces engaged on the Western Front were numerically consistent and fully equipped. The only new equipment was for replacement purposes. As well, the structures of civilian purchasing staffs had matured. This role of Civil Staffs is a wholly understudied and integral part of understanding all relationships and legal requirements to meet sufficiency.

As a note, the work makes a distinction between ordnance and munitions. For the purposes of this thesis, ordnance is, in economic terms, a durable goods product, whilst munitions are expendable goods. In other words, ordnance is considered the platform (artillery) itself while the munitions are the projectiles, propellants, fuzes and other necessary

products that are intended to be used once. This paper will be focused on ordnance industries, and not the narrower munitions issues, except when necessary to explain larger issues.

## **Methodology**

This thesis was not originally intended to challenge and revise the successes or failures of the War Office during the first year of the First World War and the circumstances surrounding the creation of the Ministry of Munitions. It was originally devised to understand the human nature in a Clausewitzian sense of government procurement from the most modern conflict that a full set of records are available for.

The research methodology for this thesis has been undertaken in multiple stages. The first stage was to gather all of the trade contracts for ordnance from Fiscal Year 1900 through Fiscal Year 1914. This gave a baseline of peacetime capacity as well as trends of British ordering. In addition, the annual audit reports of the Ordnance Factories conducted by Charles Harris were critical in compiling an accurate report of costs as well as the cost and pricing data that allowed for a view of prices between the trade and Woolwich. The Trade contracts were held at The National Archives of the UK at Kew, London (henceforth known as TNA) under WO 395/1-3. Due to the fiscal framework Woolwich worked within, its

records are held in two places, first as annual votes, and second as the audits of their annual books. These latter documents offer the most reliable year to year accounts. Both are held at the Parliamentary Archives.

Next, a review of the policy documents that educated the thinking of the Civil Service was undertaken. The *Report of the Government Factories Workshops Committee*, also known as the Murray Report of 1907, was the most important of these, although other ones also coloured the understanding of what exactly ‘business as usual’ was defined as for procurement of artillery in particular.

The papers of the President of the Ordnance Committee, or after 1907, the Ordnance Board were closely examined. These papers, found under SUPP 6 of the National Archives, have never been used in any historical work to analyse the industrial aspects of ordnance. The Ordnance Papers, and especially the Annual Report of the President of the Committee/Board, are the single source for all new ordnance, research, international espionage, and gun failures for a particular year. They are exceedingly technical in their nature, but if read through multiple years the researcher can notice trends and systematic issues. The papers were at the time given very small circulation, with only about two dozen copies printed per year. The copy that survives is often that of the Secretary. These copies were almost certainly never seen by the trade, although portions of

redacted reports created by the Board were given to the trade, usually on problems specific to their own manufacturing techniques or failures of guns they made. The papers were classified until the mid-1970s, and even now, the detail makes utilizing them as a source difficult due to the sheer volume of information.

### **Corporate Archives**

This thesis has also looked at corporate archives. Dr Graham Honeyman, CEO of Sheffield Forgemasters generously opened the archives for the first time to external research. This archive contains several accounts books for salaries between 1900 and 1925 although there is little left of technical or business matters that are pertinent to this thesis. Those looking at a full study of pay between Woolwich and the Trade would find this archive of particular use.

The largest remaining archive for the trade is the Vickers-Armstrong corporate archive. This is actually located in two different areas, with the primary holdings at the Cambridge University Library, although a substantial holding, primarily dealing with Armstrongs, which it subsumed in 1927 is located at the Tyne and Wear Archives in Newcastle. These archives were deposited the 1970s and 1980s as part of the shift in ownership of British Steel to private ownership.



The Armstrong archives in Newcastle is dominated by the shipbuilding portion of the business. This has been reported by many historians, including Ian Buxton and Clive Trebilcock who have spent substantial portions of their careers understanding these particular resources. Unfortunately, the records of the Elswick gun plant are scant. They also add little to contradict HM Government's archives at Kew.

The Cambridge University holdings of Vickers contain almost no relevant works for this thesis. The corporate published notes of board meetings survive in part, although accounting ledgers are existent for one year in this period. Also, almost no records of the River Don plant survive, and certainly nothing of a technical nature. There is not enough at Cambridge to contradict the Government's record on gun manufacture.

### Secondary Sources

Finally, the secondary literature was reviewed. This was done last as to not influence the interpretation of primary sources. This has been a useful methodology as many of the secondary sources were based upon either the Official Histories (which as will be mentioned later are untrustworthy in some instances,) and other works such as David Lloyd George's memoirs which came out in the late 1930s and were biased in its interpretation.

The literature on this subject has been lacking in both analytical substance and specificity since the Armistice. This has to do with three primary factors. First, the historiography of the arms industry to this date have been written primarily from the perspective of the Trade, through the corporate archives. The Trade archival material on gun making disproportionately did not survive, and therefore a large amount was not available for historians. Second, the British Government's archives were to a large extent not declassified until after much of the historiography was written, and historians therefore had to rely on the previously mentioned sparse corporate records or the Ministry of Munitions Official History, as will be mentioned below. The classification was due primarily to the technical nature of the reports. Third, to be properly understood gun making requires a different set of skills from every other part of the armaments field such as shell production or small arms manufacture. The author must not only have a working understanding of ballistics and physics but also be able to contextualize the bureaucracy and situations of the Government staffs, which has been missing in serious historiographical discussion.

Economic historians such as Clive Trebilcock in *The Vickers Brothers: Armaments and Enterprise 1854-1914* (1977) and David Stevenson in *Armaments and the Coming of War: Europe 1904-1914*

(1996) have examined the output of British industry quantitatively although pre-war numbers compared to wartime numbers are like apples and oranges due to the percentages spent on different classes of output. In particular, the economic study of ordnance is difficult because of macroeconomic data being unable to differentiate between purchases of new artillery and expendables such as munitions. Without separately analysing every portion of the parliamentary budget line of “warlike stores”, strictly economic studies will not reveal the full rationale behind British industrial output. Trebilcock especially has written the most important works that colour the historiography, although he wrote primarily from the side of the Trade, as well as writing his major works just before the declassification of much of the Government’s key documentation into the archives.

Political and social historians as well have contributed to the topic, although the inherent limitations of the two disciplines also leave much to be desired. Such historians such as Kathleen Burk in *Britain, America, and the Sinews of War, 1914-1918* (1985) and David French in *British Economic and Strategic Planning: 1905-1914* (1982) have written on the strategic effects of certain policies, with the former dealing specifically with the Anglo-American relationship and the latter with economic strategy. Unfortunately, for this type of analysis, technical details have to be

minimized to a great extent. This is extremely difficult to do when talking about a very technical subject such as ordnance.

A particular subset of British economic historians have also looked at the mobilization of industry as well as the long term industrial views of British industrial 'decline.' This was a particularly popular view in the 1970s and 1980s in Britain. The most well-known of these are Correlli Barnett and Chris Wrigley. Both wrote mainly in the late 1970s through the 1980s. Barnett's most notable work *The Audit of War: The Illusion and Reality of Britain as a Great Nation* (1986) looked at failures in the Second World War, although started his analysis from the 1870s. The work is not as important specifically though for the topic as Wrigley's essay *The Ministry of Munition: an Innovative Department* which can be found in Kathleen Burk's *War and the State* (1982). Wrigley's sources for the work included many of the unreliable sources such as the Ministry of Munitions Official History but also the Lloyd George Papers, and memoirs by political leaders of the period who would defend their positions in their own writing. Unfortunately, Wrigley's analysis is an exercise in hagiography as he perpetuates old myths without actually researching the underlying assumptions. Wrigley did not use a single War Office source, which led to the predictable conclusion that the War Office was entirely wrong and the Ministry of Munitions saved the nation. Many historians since Barnett and

Wrigley have negated much of this work. Historians such as David Edgerton, William Rubinstein, Peter Payne, and Bruce Collins have progressively dismantled the thesis put forth especially by Correlli Barnett.

Corporate historians have looked at the role of the Trade. Unfortunately, these works almost to a whole were commissioned by the companies they are about. Therefore they tend to give a non-confrontational view of how the company worked with the Government. As corporate histories, these works tend to glance over the war as a small part of the overall work, and cannot give the detail needed to shed light on the subject at hand. The primary two examples in this case are JD Scott in *Vickers: A History* (1962), Marshall Bastable's *Arms and the State* (2004) and O.F. G. Hogg in *The Royal Arsenal* (1962). One of the major flaws of the corporate histories of armaments firms, especially by Scott and Trebilcock, are their interpretations of the firms acting as monolithic organizations instead of separate plants within a central corporate structure. Many of these histories spend more on corporate structure than the product line. In this way, gun manufacturing is wrapped into the larger armaments sphere where it unfortunately has been interpreted as having the same issues, needs, and constraints as small arms, machine guns, armour, or even projectiles. Unfortunately, this interpretation has underestimated the role of the gunmaking plants and foundries relative to

the other lines of business, primarily shipbuilding, to great detriment. It ignores the scientific and production management that is specific to the largest and most demanding elements of the defence base by 1914.

Kenneth Warren's *Steel, Ships and Men: Cammell Laird, 1824-1993*

(1998) is one of the better corporate histories of the ordnance firms that break down the lines of business. The need to cover long stretches of time tends to be the greatest weaknesses of these works, which leads to few pages being spent on important events such as First World War.

A dangerous element of the corporate histories that is particular to the ordnance industry in Britain has nothing to do with the time under study, but the subsequent fifty years. Vickers purchased Armstrongs in 1927 and subsequently became the single surviving gun maker after the competition, mainly Coventry Ordnance Works, although others such as Beardmore closed or amalgamated, all eventually being merged in the 1990s as British Aerospace, now BAE. Historiographically, Vickers dominates the secondary literature, yet this is not representative of the industry as a whole. As will be demonstrated, it was actually the exception to the industry in many cases. Vickers's dominance in business, especially after 1919, was what led to their success, and therefore to corporate histories which dominate the literature. The dominance of Vickers has a great deal to do with the availability of archives.

Military historians have also entered, not surprisingly, in the aforementioned subject. The vast swathe of First World War literature has gone into great detail about the Royal Regiment of Artillery, the Shells Crisis of 1915, as well as artillery doctrine. Unfortunately, the recurring theme of all is the focus of artillery's effects on operational conflicts, mainly on the Western Front. These historians almost wholly focus on combat arms to the detriment of staff work, especially that of a technical nature. Part of the stance was that there were only a handful of Royal Artillery officers who had technical ordnance experience above their traditional operational and tactical experience. Even fewer historians have researched the technical issues of ordnance procurement. Military historians have also completely ignored the role of civil servants in the War Office and their effects on operational efficiency. Ian Hogg was probably the most prolific of writers on the technical elements of land-based artillery and his book *Allied Artillery of World War I* (2004) analyses the subject in detail, although the lack of footnotes or academic rigour of citation does not allow the book to be utilized for scholarly purposes.

Naval history is seriously lacking in the same respects as military history. Although Jon Sumida with *In Defense of Naval Supremacy: Finance, Technology, and British Naval Policy 1889-1914* (1989) does discuss armaments, he is more interested in the optical and other

revolutions in armaments that occurred parallel to the period in question. Ian Buxton has written extensively on the technical side of naval architecture and the naval shipbuilding industry in Britain, although he has assumed much of the conventional thinking on how the aspect of how guns were procured for the Royal Navy without the War Office records. Ian Hamilton in *The Making of the Modern Admiralty* (2011) has executed a sweeping history of the Admiralty bureaucracy, although no work has yet been completed on the Royal Navy Contracts department and Director of Naval Ordnance civil staffs, in particular. Hamilton's is still the best book currently available of the evolution of any Civil Staff on Whitehall. There does not appear to be a single work from the naval perspective on the relationship between the Director of Naval Ordnance, the War Office civil staffs (who bought all naval guns for much of this period), and Woolwich and the trade. Due to the nature of the naval war, including relatively few naval battles, there is even less operational history than the military efforts.

By far the two most important authors cited in the secondary literature of all the disciplines mentioned above are Clive Trebilcock's *The Vickers Brothers: Armaments and Enterprise 1854-1914* (1977) and 'The British Armaments Industry, 1890-1914: false legend and true utility' in Geoffrey Best's edited work *War, Economy, and the Military Mind* (1976) and J. D. Scott's *Vickers: A History* (1962). These three works dominate



the historiography, and are cited in virtually every secondary work since. Therefore, even new works on the subject are based upon works that are now over four decades old. Most importantly, although ground-breaking in their day, the works of Trebilcock and Scott did not incorporate the classified government records that were not wholly released until the 1990s. Their dominance based upon one perspective (the trade) of a much more complex situation has led to the subsequent skewing of all secondary works, many of which are surveys and comparative studies of larger topics in which British gunmaking is but a small part.

### **Primary Sources**

The Official History of the Ministry of Munitions was published right after the war in 1922. It consists of eight public released and four ‘classified’ volumes released later which have become the most widely cited text by every school of historian listed above. It was hastily pieced together between 1918 and 1922. In it the work of the War Office and its leader, the late Lord Kitchener, were downplayed. The untimely death of Lord Kitchener whilst the Secretary of State for War gave David Lloyd George a political opportunity as the story could not be openly challenged by one side. The mythology of Lloyd George and the Ministry was forged at that time and has been perpetuated since in later works. Some of the myths

perpetuated by the 12 volumes, especially that about the first year of the war and the state of industry in May 1915, is in direct contradiction to the official documents released in the last 30 years that are housed at TNA. The historical section deposited their papers and chapter drafts under the Ministry of Munitions papers, MUN series, which now reside at TNA. (As a note to the reader, The National Archives is the rebranded title of the old Public Records Office (PRO) that is often used in older works to cite the same documents.) It is telling that even the drafts of the historical branch were classified for 50 years.

This thesis from the beginning of research has tried to ignore work written after 1918 on both sides to come to an unbiased conclusion as to the reality of industrial mobilization for gun production. This is the primary reason for a heavy reliance on archival papers as well as the use of previously unused sources such as the Ordnance Board. This thesis has tried to get beneath the political level to understand what was actually happening, by those who were making the daily decisions. Because of this, this thesis intentionally does not rely on the memoirs of political leaders, unlike all other works written directly about the subject.

The only real contemporary challenge to Lloyd George's version of events to the British wartime effort was to come from a three-volume series on the late Lord Kitchener from his personal secretary, Sir George Arthur.

Major General Stanley von Donop, who was the Master General of Ordnance during Kitchener's time at the War Office, was requested to write notes on the former Field Marshal's performance in the first year of the war in regard to industrial mobilization. Lloyd George while Prime Minister personally intervened against the publication of his notes in October 1919, stating that they were 'not suitable for publication, in that they constitute in substance an attack on the Ministry of Munitions and this will inevitably lead to a controversy between Departments which will be detrimental to the public service.'<sup>1</sup> There are at least two copies of von Donop's original paper submitted to Sir Arthur, one of which can be found in the Lloyd George Papers in the House of Lords Archives under LG F/191/2/2 and the other in Stanley von Donop's papers housed at TNA under WO 79/84. Importantly, both copies are identical except for the markings in pencil of certain sections of each of their respective owners. The censorship of the only remaining high ranking critic of the Prime Minister cleared the way for only one dialogue: that of the published Ministry of Munitions Official History. It should be noted that the Ministry of Munitions did not shirk from attacking the War Office for its policies in the official histories, thus making public a toxic situation.

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<sup>1</sup> LG F/9/1/39 Letter Davies to Brade. Returns emended letter to von Donop, as approved by Lloyd George. 23 October 1919.

This thesis is not meant to be a repeat of what was censured almost 100 years ago, although many of the sources used by von Donop in his defence of Kitchener are used in this thesis, along with some that he considered too controversial to use. These add to the voluminous technical information that predated his time in the position which lasted from 1913 through 1916, thus making this thesis a rebalanced and complete view of the subject, incorporating for the first time all documentation from multiple departments over a span of almost two decades.

This thesis follows a chronological layout. The first seven chapters discuss elements of pre-war policy in theory and practice. The last three chapters analyse the ability of British industry to perform the policy in practice. The chapters as a whole will demonstrate what peacetime policy was, how effective that policy after wartime shock, and for the reasons that effectiveness was based upon.

## **CHAPTER TWO: BRITISH GOVERNMENTAL POLICIES ON DEMAND OF ARTILLERY, 1900-1914**

‘War is competition; there is no standard of excellence for anything; it does not suffice to have good material, good soldiers, and good officers, if the enemy has better material, better soldiers, and better officers.’  
- Brigadier General William Crozier, US Army.<sup>2</sup>

### **Introduction**

When William Crozier wrote to the United States Congress in his 1902 annual report, he distilled the essence of how the then nascent century would evolve. He understood that the product of the Second Industrial Revolution was an increased efficiency of industry worldwide, and that the professionalization of the world’s officers and enlisted men meant that a true industrial war was not out of the question. He also wanted to impart to those policy leaders in his audience that industrial policy and thought had to be an integral element in strategic thinking in the new century for any country.

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<sup>2</sup> William Crozier. *1902 Annual Report to the Secretary of War, Volume 7*, (Washington: Government Printing Office, 1902), 20.

This chapter will discuss the underlying culture within which the British Civil Service and military officers managed British defence industry policy as it pertains to the procurement of artillery tubes for the Royal Navy and the British Army. This chapter analyses the demand side of the ordnance industry, or in other words what the military needed and what policies and decisions were made to satisfy those needs. The underlying purpose of this chapter, in conjunction with chapter three, is to build an understanding of what the British strategic position was in regards to artillery at the outbreak of war, thus leading to subsequent chapters that will discuss how effective these peacetime policies were when the supply chain was stressed and demand was escalated.

Governmental industrial policy must be two-fold. First, industry must be able to produce the material needed for the ordinary operations of a peace-time military at a cost that is reasonable to the taxpayer. Second, industry must be able to produce the material needed for the extraordinary operations of war at a rate that is reasonable for the user, in this case the Royal Navy and the British Army. This paradox, and its management, is one of the most difficult of sovereign tasks. Throughout history, especially in the industrialized period of the last 200 years, those who have succeeded usually thrive, and those who have not, lose. It is this paradox that the following attempts to provide light on, through the

historical context of the British experience from the conclusion of the Boer War (1899-1902) to the American entry into the First World War in the spring of 1917.

The policymaker's task in managing the paradox is seemingly straightforward. The armed forces must be equipped, and the industrial might that is needed to create and sustain the force must not be such a burden to the economy as to overly affect commercial practice while also not cost so much as to unduly burden the tax base. By the end of the 19<sup>th</sup> century, every western country had developed their own style of how to proceed. Each tailored the base to the particulars of the localized culture and resource abilities. What follows in this thesis educates and enlightens policy decisions followed by the United Kingdom through the medium of artillery tube demand and production.

### **Bureaucratic and Political Foundations**

All acquisitions inevitably start with the political needs of the state, and to understand its decisions, inevitably it must be known how the leaders were placed in their positions. Since the Glorious Revolution in 1688, Great Britain has generally worked under a constitutional monarchy. Nominally headed by the Monarch, a King or Queen, the Government works in a legislature composed of two parliamentary houses: The House

of Commons and the House of Lords. The former operated on the basis of elected representation of the enfranchised population, composed traditionally the wealthy and increasingly an expanded percentage of the population gained enfranchisement. 1715 saw the passage of the Septennial Act which mandated elections of the House of Commons no more than seven years from the first meeting.<sup>3</sup> The House of Lords through the end of the Edwardian period in 1914 was composed of hereditary peers.

The vast majority of the power of Government resided in the Cabinet, an organization based on the results of the last election, and in the likely case in this period of no single party gaining the absolute majority, the ability of parties to create a coalition Government, which would be led by the Prime Minister, who was often the head of the majority party, but not always. The Cabinet consisted of Members of Parliament (MPs) as well as peers from the House of Lords, who were assigned as political overseers of civil service led departments. Of these the 'Great Offices of State' hold the most power and seniority. These consisted of the Prime Ministership (through the joint title First Lord of the Treasury), the Chancellor of the Exchequer, the Foreign Secretary, and the Home Secretary. Many other members made up the Cabinet, with varying degrees of work, for both

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<sup>3</sup> *An Act for enlarging the Time of Continuance of Parliaments, appointed by an Act made in the Sixth Year of the Reign of King William and Queen Mary, intituled An Act for the frequent meeting and calling of Parliaments.* (1 Geo 1 St 2 c 38. 1715)



bureaucratic and party purposes. One of the novelties of the Cabinet was that once a Member was appointed, the group made decisions for the Government as a whole, as compared to those making decisions based on the sole needs of their particular assigned responsibility.

### **Finance**

The control of the purse is arguably the most important aspect of any government. Therefore an analysis of governmental industrial policy must start with the financial constraints placed upon it. By the 1880s the funding of the government became the primary way in which the House of Commons kept the civil service in check. The civil service, through departments of the Government, provided the daily administration required. The Admiralty and the War Office, the administrative constructs of the Royal Navy and the British Army respectively, for example, were run primarily by civilians. It was this corps of professional career bureaucrats that contained the skills required to interpret, manage, and execute the systems required to keep the respective fighting services outfitted and in the field in fighting order. The procedure for funding government followed several steps including: creating an estimate in the Office, political secretary approval, submission to the House of Commons, approval by both houses and the Sovereign, and disbursement through

expenditure. This process seems simple, but any of these steps could derail the entire system.

### Votes

The processes of creating the budgets were relatively straightforward. ‘Army and Navy estimates are prepared under the direction of the Secretary of State for War and the Board of the Admiralty whose signatures they bear. These Estimates are submitted to the Treasury for sanction before presentation, but they are laid out before Parliament by the Ministers of the War Office and Admiralty respectively.’ This annual process was started by a letter sent by the Treasury to the Accounting Officers in their respective Departments requesting the estimates to be delivered in draft form to the Treasury by 1 December. The Treasury then scrubbed the numbers and ascertained all details to support the requested number. Interestingly, the Treasury instructed Departments to create new budgets every year instead of relying on previous years as baselines. This would have required a program to be continually justified throughout its life.<sup>4</sup>

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<sup>4</sup> *Report from the Select Committee on National Expenditure.* (London, UK: House of Commons Select Committee on National Expenditure, 1902), 191.

The nature of the Estimates process would have been complicated and foreign to all but the most seasoned senior clerks in Departments. Therefore, the Treasury, through the Exchequer and Audit Departments Act of 1866, provided Treasury staff to those Department employees assigned with estimate work.<sup>5</sup> The Act was designed to create uniformity through the financial offices of the Civil Departments and introduce a standard of accounting hitherto non-existent on a Government-wide scale.<sup>6</sup> It became apparent by 1872 that the increasingly complex nature of the budgetary process required extraordinarily skilled accountants. Those Department accountants charged with creating the Appropriations Accounts were therefore entitled Accounting Officers, and with the title, were the only ones with the authority and personal accountability to certify the Estimate of the Department.<sup>7</sup> This Treasury Minute also formally renamed those who had held the title of ‘accountant’ to ‘Clerk in charge of the Accounts’, thus eliminating any possible confusion on important matters of accounts. Through experience gained by the 1866 Act, the House of Lords came to the opinion that the Accounting Officer should be a permanent member of the Department given the authority by the

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<sup>5</sup> Ibid. 204.

<sup>6</sup> Ibid. 205.

<sup>7</sup> Ibid. 204.

Department to represent the said department before the Parliamentary Committee of Public Accounts<sup>8</sup>

In 1883 the details of the extent to which the Accounting Officers were to be held personally responsible came into question. At that point, The Treasury let it be known in a circular that they were, through any legally binding finance law, required to take responsibility for every payment in their Department.<sup>9</sup> This difference, although subtle, meant that the Accounting Officer was to be held responsible for all financial transactions, from the Estimate through the final audit. This also meant that, through association, the Accounting Officer served as the responsible party for all contracts and business transactions conducted by the Department. When the Accounting Officers were placed in responsibility for all expenditure, they were also de facto meant to be the overarching authority of all appropriation, obligation, allocation, and payment. Therefore, the powers of warrant of the contracting officers and other business personnel were channelled and granted either formally or through inference, to the Accounting Officer.

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<sup>8</sup> Ibid. 205.

<sup>9</sup> Ibid. 206.

## Staff Issues

In regard to personnel, every civil and military position had to be accounted for on a yearly basis, reporting both increases and decreases to billet balance and financial estimates in comparison to previous estimates. Departmental Accounting Officers were required to present reports on their human capital to a full audit before the Treasury signed off on the Estimates.<sup>10</sup> In the two uniformed Departments, War Office and Admiralty, the accountability in detail usually lay in the hands of divisions broken up for budgeting reasons. These divisions were called Votes. Each Vote represented dedicated money that could not be spent outside of the restrictions of the appropriations acts unless authorized by the House of Commons. Ordnance fell under the vote of ‘warlike stores’ which classified everything that was essentially not a commercial item, such as firearms, artillery, propellants, torpedoes, munitions and the like. In the War Office as well as the Admiralty budget, this held the traditional ‘Vote 9.’ Votes were also inclusive, and covered funds that were going to be expended both in the Trade and at the Royal Factories. When the Treasury created the Votes for the War Office and Admiralty during the Second Boer War, the War Costs were not included in the normal Vote, and were included in

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<sup>10</sup> Ibid. 192.

a supplementary Vote that could better align with accounting practices as well as making a difference between ordinary and extra-ordinary costs of the services.<sup>11</sup>

The Treasury maintained control over departments through three tools: Control over Estimates, control over the expenditure under Votes, and the control of details.<sup>12</sup> In this regard, the Chancellor had the potential for great power in the Cabinet, and could drive major policy in the Departments through the power of the purse. Of these three, the control of expenditure had the greatest effect on ordnance, although the control of details greatly influenced capital investment, an issue that was important to the control of the Government Factories.

### **Budgets**

Each budget covered a Fiscal Year (FY) from 1 April until 30 March of the next. It was traditional for the Government to use the year in which the budget ended as the budget year if only one number was used. For example, a budget that started on 1 April 1902–30 March 1903 would usually be cited as the 1903 FY. With very few exceptions, all funding for the purposes of the Government followed the FY as opposed to a

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<sup>11</sup> Ibid. 194.

<sup>12</sup> Ibid. 197.

Calendar Year (CY) which would have spanned from 1 January–31 December.

Budgets covered 12 months of expenditure only. All funds had to be at least allocated and obligated, that is, spent, or put on a contract, by the end of March every year. Once the end of the FY was reached, all unobligated funds would expire and revert back to Treasury accounts. Large, multiple year contracts such as shipbuilding were also allocated one-year funds, and thus the contract would cite the entire number, and reserve the funds in an allocated pool, although they might not be paid out or expended for several years for example at the point of acceptance of the goods delivered. The Vote would fully fund projects at the start. It does not appear that the Treasury placed any restrictions on the expiration of obligated funds output, meaning that capital asset contracts such as shipbuilding do not appear to have an arbitrary end date by which contract invoices had to be closed.

As part of the control over the expenditure under vote, funds from the same FY could not be transferred from one Vote to another without the authorization of Parliament and the Treasury.<sup>13</sup> This process, called virement, was put in place on the War Office and Admiralty budgets

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<sup>13</sup> Ibid. 197.

through ‘Mr. Monk’s Resolution of 4<sup>th</sup> and 5<sup>th</sup> March 1879.’<sup>14</sup> This resolution was, strictly speaking, a shift of power from the Departments to the Treasury, which had the ultimate real say on virement. Thus a surplus in one portion of the budget could not meet a deficit in another. This restriction limited the absolute control of Departments to manipulate budgets or spend monies that were not specifically coloured for the said purpose. At the end of each FY, the Treasury Audit Office would analyse each Vote’s obligated and spent amounts to verify the maintenance of proper expenditure of public funds. This audit was a long-standing requirement, first entering the Navy Votes in 1832 and the Army Votes in 1847.<sup>15</sup> The audit was an independent and comprehensive study of the books, with the auditors having freedom from the chain of command and a guarantee against the censorship of any part of the report. Audits had to take into effect not only the voted Parliamentary Estimates, but as well any Acts or Orders in Council that refined or specified particular Votes.<sup>16</sup>

Once the Votes were approved, the services could start the work of obligation. For the Army, Vote 9 represented warlike, &c, stores. For the Navy, Vote 9 was Naval Armaments. These two votes are the only parts of the financial budget of interest for the topic of this paper, although

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<sup>14</sup> Ibid. 197.

<sup>15</sup> Ibid. 210.

<sup>16</sup> Ibid.



commands such as Woolwich would have pulled their funds from many different Votes from several different Departments to properly conduct the wide ranging businesses conducted there.<sup>17</sup>

### **Bureaucracy**

In the case of the British Army, the passed vote was then managed by the civil staff of finance at the War Office, whose headquarters was located in Whitehall, a street near the Houses of Parliament in London where many governmental offices are located and which has become synonymous with Britain's central governments. The Army Finance Department was, after reforms in 1905, a voting member of the newly formed Army Board, under the title of Financial Secretary to the War Office. The office of Financial Secretary after 1905 was held by an MP although the position never sat on the Cabinet. The Assistant Financial Secretary, a position created in 1908, was a senior civil servant, Sir Charles Harris. Under him, three departments managed all funds for the army: the Director of Army Finance, the Director of Financial Service, and the Director of Contracts. Each of these in the period studied were manned by senior civil servants, with their responsibilities for each determined by statute. Within these three offices, the finance office had six Principals

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<sup>17</sup> Ibid. 199.

assigned to it, all civil servants. Although the offices were reorganized, the same Principals were essentially in the same post from 1905 until 1914. As well, the Director of Contracts was assigned one Assistant Director of Contracts, acting in the same manner as the Accounts and Finance civil servants. Under these, there were on average eight clerks, which would have also included various under clerks, and boys. What is striking is the small scale of this office, which dealt with all transactions of currency, from budget creation, to contracts, to payroll. The entire finance department was in all likelihood under three dozen staff from top to bottom.<sup>18</sup>

In the case of the Royal Navy, the Admiralty was structured in a similar manner to the Army Board, primarily because the army copied the idea from the proven bureaucracy of the Admiralty Board. The Admiralty bureaucracy was headed by the Controller of the Navy, usually a Rear Admiral, assisted primarily by the Accountant General of the Navy as well as by the Director of Navy Contracts. The most striking departure though from the army's organization was the size of the staff dealing with financial issues. In 1900, the naval civil staff consisted of two branches: the Contracts Department and the Accounts Department. The Contracts Department consisted of two directors, two chief clerks, four clerks, eight second-class

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<sup>18</sup> The *Army List* was published quarterly in peacetime (Jan, April, July, and Oct), and during the war was published monthly. The information used was taken from the January editions of each year.

clerks, nine superintendent clerks, and four boy copyists. The second, and larger, office dealt with accounts, and consisted of one head, one department chief, nine superintendent clerks, fifteen assistant superintendent clerks, fifteen staff clerks, and one hundred twenty four 2<sup>nd</sup> class clerks, fifty-eight supplementary clerks, and twenty-six boy copyists.<sup>19</sup> This striking contrast in size between the tasks of contracts and accounts represented not only the bureaucratic apparatus that the Admiralty placed on accounts, but also the entrenched and long-standing nature of that office, which had been active since the 1830s.

### **Bidding**

These two organizations within the framework set forth in Westminster legislation and policy set the basis for ‘business as usual’, a term often used by historians to describe the peacetime processes of the War Office. It was within this framework that all administration functioned. The demand by the Government for all goods, including guns, was forced into following the above procedures, through the above channels, for the entire period of study. How the administration designed its purchasing and procurement tactics, including how the government interacted with industry as well as specific unit demands and ultimately

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<sup>19</sup> Navy List, January 1901.

force structure would all be determined within the tight constraints of Vote administration.

The actual bidding process is best described by a note written in 1906 by the Admiralty staff.

‘First, Admiralty demand, specifying descriptions and quantities of stores to be ordered, is passed to Chief Inspector, Woolwich, for him to insert particulars of specification, sealed drawing, &c. 2. Demand is returned by Chief Inspector to Admiralty. 3. Demand is passed from Admiralty to War Office for tenders to be invited. 4. Tenders are then called for by War Office. 5 Tenders are received at War Office and there scheduled. 6. Tenders are examined by War Office Departments and then passed to Admiralty, with proposals as to acceptance. 7. Tenders are considered by Admiralty, and returned to War Office with a notification of their Lordships’ decision. 8. Tenders are accepted by the War Office, and copies of tenders supplied to Admiralty.’<sup>20</sup>

In general, 1/3 of all orders for guns were given immediately to the Royal Ordnance Factories and 2/3 to the trade, which until after 1905 was composed of Vickers Maxim and Armstrong Whitworth. For smaller guns

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<sup>20</sup> WO 33/2960. Report of the Committee appointed to consider methods of inspection and delivery of naval ordnance and naval ordnance stores. 63.

(those under 6 inches) in general the lowest bidder received the contract, but for larger guns, 50% of the remaining order was given to each of the two firms equally.<sup>21</sup> The procurement of the 3-inch quick firing Vickers gun, along with the competition for new field guns created a massive headache for the Treasury Solicitors over the 1904 Christmas season. The situation of Vickers and Armstrongs was stated as: 'There is, moreover evidence that Messrs Armstrong and Messrs. Vickers have for some time past been more friendly co-operation than in a state of rivalry as regards supplies to His Majesty's Government, and therefore this Department welcomed the offer of Messrs Cammell, Laird & Company Limited to equip themselves for the making of guns as more genuine competition would thereby be ensued'<sup>22</sup> This slightly changed in April 1908 when the Chief Inspector of Naval Ordnance was created as an attempt by the Admiralty to get closer to the business of procurement, although the office was only of marginal success in the short term.<sup>23</sup> By then, though the Admiralty had dropped their protest of allowing Cammell Laird to bid for contracts, and in February 1906, the Admiralty and the War Office agreed to allow competition from outside the traditional late Victorian suppliers.<sup>24</sup>

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<sup>21</sup> ADM 1/7897. D.N.O. Director of Naval Ordnance In-letters 1906 Feb.

<sup>22</sup> Ibid. Letter, H.G. Ward to Admiralty. 6 Nov 1905.

<sup>23</sup> ADM 1/8010. Instructions for the Chief Inspector of Naval Ordnance. 11 April 1908.

<sup>24</sup> ADM 1/7897 Letter 2 March 1906. War Office to DNO.

As a matter of British bidding policy, orders were almost exclusively placed with British firms. All warlike stores after 1900 were placed with domestic suppliers, although this was a matter of policy more than legal requirement. Foreign purchases of non-warlike stores required the approval of the Financial Secretary for final permission. The most common foreign orders year on year were for horse shoes and acetone, both of which were more economical to produce outside the UK.<sup>25</sup> This was shown in a case in 1902 where it was approved, but only because the domestic source was 142% of the foreign bid.<sup>26</sup> Domestic sourcing became the bidding policy for warlike stores throughout the peace.

### Policy

The election cycles in the first decades of the century demonstrate changes in the government majority at Westminster. The 1900 General Election brought the Conservative Party with their Liberal Unionist Party coalition to power, first from the election until 11 July 1902 under the leadership of the Marquess of Salisbury (Robert Gascoyne-Cecil), and then from 11 July 1902 until 5 December 1905 under the leadership of Arthur Balfour. The 1906 General Election saw the return of the Liberal

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<sup>25</sup> WO 395/1, Annual Reports 1873-1903; WO 395/2, Annual Reports 1903-1908; WO 395/3 Annual Reports 1909-1914.

<sup>26</sup> WO 254/1. Contracts Precedent Book.

Party establishing a majority government. This Government was led by Sir Henry Campbell-Bannerman until April 1908 when Herbert Asquith replaced him as the Liberal Prime Minister. Asquith and the Liberal party survived the 1910 General Election and remained in government until 1915.

Policy after the Boer War came from many different areas. The reforms to save money were paramount, although the need to reequip combat troops was also the top need of the army. This project would eventually lead to a £1,000,000 expenditure to reequip the Royal Horse and Royal Field Artillery Regiments, the largest British Army contract in history to that date.

Ordnance played an odd role as a unifier in regards to military and naval staffs. Unlike every other purchase or piece of equipment deployed by the forces of Britain, ordnance had DNA from both the salt of the sea and the dust of the deserts. In this period, every decision regarding ordnance was reviewed, analysed, and approved or dismissed by representatives of both services. This oddity is best represented through the lens of a report from the Committee Appointed to Consider Various Questions Concerning the Methods of Inspection and Delivery of Naval Ordnance and Naval Ordnance Stores. This committee, if it had been to study any topic other than ordnance would have been composed

exclusively of naval officers, but instead the group was composed of three naval officers, three Army officers and two Whitehall civilians.

Represented were men in some of the highest technical positions in the British Government, including: the Master-General of Ordnance, the President of the Ordnance Committee, the Director of Naval Ordnance, the Director of Artillery, the Superintendent of Ordnance Stores (Naval), the Chief of the Financial Department, War Office, and the Accountant General of the Navy. Each of these positions held key pieces of the puzzle that was ordnance. Each piece contributed in its own way to produce and purchase everything that exploded at sea and on land.<sup>27</sup>

### **The Master General of Ordnance**

The Master General of Ordnance (MGO) was the most powerful individual in the government in regard to ordnance policy. The Master General of Ordnance position had existed in many different forms for well over a century, first as the Master General of the Ordnance part of the Board of Ordnance, which was dissolved in 1855 after the Crimean War debacles in supply. The position was then rebranded Director of Ordnance, and finally the 1904 Esher Report and reforms made the

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<sup>27</sup> WO 33/2960. Committee Appointed to Consider Various Questions Concerning the Methods of Inspection and Delivery of Naval Ordnance and Naval Ordnance Stores. 1.



reflagged office of Master General of Ordnance (without ‘the’ in the title) the fourth military member of the six-member Army Board.<sup>28</sup> As a voting member of the Army Board, he was to represent the design, manufacture, and use of all weaponry and associated equipment. Between the Master General of Ordnance and the Quartermaster General, all equipment required to field the British Army was represented.

The Master General of Ordnance was tasked with the design and policy of all ordnance for the government. The task was in reality executed by a group of serving officers from both services. This was an unusual case of interservice synergy that military and naval historians have missed in this period. This group was an inheritance from the old Board of Ordnance, and the Master General of Ordnance appointed the group’s head. The President of the Ordnance Committee and, after 1907, The President of the Ordnance Board was the Master General of Ordnance’s representative in the technical aspects of ordnance. The Committee/Board of Ordnance was a truly diverse group of officers as members and civilian associate members who were charged with running the daily and strategic functions of all things ordnance. The Presidency of this group traditionally rotated between a naval and army flag officer, with the other service providing the vice president of the group. After the Boer War, though the presidency

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<sup>28</sup> War Office (Reconstitution) Committee. *Report of the War Office (Reconstitution) Committee*. Part III. (London, UK: : House of Commons, 1904). 8.

was dominated by a string of generals, although due to the composition of the group, this appears to have not altered the balance and bias of the group in favour of one service over another. The Board was the lead agency in running experiments, testing, inspection, interaction with the trade, specification, and design for all British ordnance.

Importantly, the Ordnance Board has received no historical study of its role in the British military hierarchy. Its papers, held under the SUPP 6 headings at The National Archives, have been scantily researched. This is especially true for histories of the British Army. Traditional histories of the service primarily deal with operational history, which often focuses on the role of the infantry, with little understanding of the role of the Royal Regiment of Artillery within the larger context. There have been recent studies on the evolution of artillery tactics, most notably Sanders Marble's *British Artillery of the Western Front in the First World War* (2013). Such books though do not engage with how ordnance was designed or manufactured, nor with technical issues such as the cost or useful life of guns.

The historiography of the Royal Navy is by the very nature of the service, more interested in manufacturing issues. Ian Buxton is currently the preeminent writer on the British naval shipbuilding industry as a whole in the period under study. His most recent book, *The Battleship Builders*

(2013) co-written with Ian Johnston, discusses the ordnance trade, especially Vickers and Armstrongs, although many of these studies are based upon secondary works that are now quite aged and based on mediocre research.

The contrast between historiographies reflects the greater capital intensity of the naval service. Officers and the general public were more aware of the industrial needs of the navy. In Britain, the peacetime army has traditionally been small, and before 1900 manufacturing occurred within the confines of Government-owned factories, with low public prominence. Only in wartime did the army require vast industrial resources on the scale of a peacetime navy. In addition, very few army officers were engaged in managing the army's industrial supply, and thus fewer people had experience in it.

### **The Service Technical Chiefs and Staffs**

The Director of Naval Ordnance was the chief naval lead in all things explosive. Traditionally a Royal Navy Captain billet, the DNO as the office was known, was a very powerful force in the bureaucratic hierarchy of the Admiralty. The Director of Naval Ordnance made the leap between the ordnance deployed in units afloat and the experimental, research, and fiscally oriented Ordnance Board.

The Director of Artillery was the professional head of the three regiments of artillery in the British Army; the Royal Horse Artillery, the Royal Field Artillery, and the Royal Garrison Artillery. The Director of Artillery managed the requirements in the field and all other professional development of the Royal Regiment of Artillery. The Director of Artillery was the bureaucratic head of all gunners, although he was not the operational leader, the role that befell the Commander of Artillery, also in peacetime a Brigadier General.

The Superintendent of Ordnance Stores was the Admiralty's operational expert for ordnance. Theoretically under the power of the Director of Naval Ordnance, the Superintendent was the manager of all delivered ordnance assets to the Navy. His input into experimental and pre-production equipment was limited, and he was almost never consulted directly by the Board of Ordnance, although he was often consulted by the Director of Naval Ordnance in the above's submissions to the Board.

What is of most interest to historians is the lack of input the Director of Artillery and the Superintendent of Ordnance Stores had on managing the industrial base. Once either officer created a requirement, they had little chance of formally steering what end product the user community received. The annual reports of the Ordnance Board and Ordnance Committee found in the SUPP 6 papers at the National

Archives, suggest that little input was asked for and little was given. In large measure this was because both the Board/Committee and the operational leads, the Director of Artillery, and the Superintendent reported to the Master General of Ordnance (the Superintendent through the Director of Naval Ordnance). This was most clear in the War Office, where the operational leads were not under the same member of the Army Council. This potentially, and in reality did, provide the best ordnance to British forces based on scientific study, and not on bureaucratic bias. This key foundation must be understood to comprehend all decisions of procurement as well as any strategy dealing with armaments on both surf and turf.

### **The Financial Staffs**

If money is power, then the Chief of the Financial Department, War Office was one of the most powerful men on Whitehall. The Finance Department of the War Office was the land warfare lead for not only the budgeting process but also the manager of finances for the Royal Factories as well as the liaison between the War Office and the Treasury. This position was held from its creation through the end of peace and beyond by Sir Charles Harris, one of the senior, long-term, civil servants who helped the bureaucracy run smoothly.

The Accountant General of the Navy was the Admiralty counterpart of the Financial Department, War Office. The position was also one held by senior civil servants. It had been established as part of the Admiralty reforms of the late 1820s and early 1830s that attempted to professionalize and streamline the staff work involved in managing the massive bureaucracy that was the Royal Navy.<sup>29</sup> Its holder was supposed to answer directly to the Parliamentary Secretary, although as much financial work was long-term, the real power still remained with the Civil Lord.<sup>30</sup> He was to advise the Board of Admiralty on financial issues as well as performing the audits that would confirm his independent status. This role in particular created and disseminated the free flow of accurate and up-to-date information on all financial issues through the sea service.<sup>31</sup>

### Parliamentary Reporting

In 1903, Parliament released the *Report of His Majesty's Commissioners Appointed to Inquire into the Military Preparations and Other Matters Connected with the War in South Africa*, which has since been known as the Elgin Committee Report. The findings and suggestions from this document were far-reaching, and set the strategic parameters as

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<sup>29</sup> C. I. Hamilton. *The Making of the Modern Admiralty: British Naval Policy-Making 1805-1927*. Cambridge: Cambridge University Press, 2011. 60.

<sup>30</sup> Ibid. 125.

<sup>31</sup> Ibid. 190.

to how the land forces were to be organized, and therefore how they would be able to be utilized. A far-reaching report such as Elgin's might as often as not have been shelved, had it not been for the composition of the committee that wrote it. For the purposes of ordnance, the report affected the technical branches little.<sup>32</sup>

The following year the War Office (Reconstitution) Committee met to look into needed reforms within the Army in light of the Elgin Report.<sup>33</sup> The Esher Committee, as it became known, proposed a massive reform of the combat arms, although, as in the Elgin Report, the technical staffs (and especially the ordnance staffs) would remain relatively unreformed. There were what appeared to be large shifts in reorganization of the staffs, but these shifts had little to do with the actual workloads or assignments. The Ordnance Board was to have all the powers that had been in the 1855 reforms of the Board of Ordnance. The Master General of Ordnance remained the ultimate power over the Woolwich Arsenal complex and his inspectors remained in their assigned positions.

The Ordnance Committee (and after 1908, the Ordnance Board) represented the true technical knowledge for the government as a whole.

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<sup>32</sup> *Report of His Majesty's commissioners appointed to inquire into the military preparations and other matters connected with the war in South Africa.* (London, UK : House of Commons) 1903.

<sup>33</sup> War Office (Reconstitution) Committee. *Report of the War Office (Reconstitution) Committee.* (Parts I., II., and III)

The Committee/Board consisted of technical members of both the Army and Navy, and their decisions tended to represent the interests of the government as based on sound scientific principles, responsible fiscal prudence, and the two services joint effort of requirements in technical matters. The group met to discuss and act upon problems and strategies, as well as foreign intelligence for all ordnance issues.

### Challenges of Ordnance

Ordnance in the period under study was the most technical element in any army or navy. It also was left almost exclusively to the military, to the exclusion of the civil service. The skills required of an officer engaged in its design, production, inspection or management differed greatly from any other engineering skill. It was even more exotic to officers of the line, the eventual end users. All operations require equipment, and more often than not, the limitations of its design commanded doctrine as a whole.

Ordnance officers through the development of technology had to be the lead innovators of the service, through design, production, or as managers of acquisition. Although naval architects might sketch out battleships, without well-executed ordnance, a ship of war is no more than an expensive ocean liner. Likewise, field guns that lacked range or mobility left an unprotected and underpowered infantry exposed in the field.



Although British taxpayers wanted to give their soldiers the best, ordnance staffs still dealt with economy, a byword for both cost and price. The latter is simply the amount of Pounds Sterling required for the needs of the service. The former is a much more difficult concept to appreciate, even in hindsight. Every expenditure by the Treasury required not only an assessment of pros and cons, a best-use analysis, and other economic appreciations, but also a concerted calculation of political worth to all stakeholders of the process. This appeared in influences from party platforms to individual Members of Parliament to the user communities to members of the trade at all stages of the supply chain. In almost every funding debate, the Hansard is filled with these sorts of questions. In the cost realm, the price of military expenditure can sometimes be secondary to real and perceived issues at the forefront of a host of groups and individuals. These calculations became driving points for the post-Boer War army and navy.

### **Murray Report (1907)**

1907 saw a major rethink of how the Government acquired warlike stores. The Murray Report was the latest in a series of reports and committees since at least the reopening of gun orders to the Trade. Many of these studies undertook to manage the capacity of both personnel and

plant. The government accountants always looked to save money wherever possible, and the Woolwich Arsenal especially was seen as a place not only for experimentation, but also for possible income. These studies were as diverse as the complex itself, from a 1902 War Office report on the management of the factory to a critique of the need for the Birmingham Small Arms Factory, which was sold off as excess in 1905.<sup>34</sup> Woolwich and the other factories were the largest and most complex of all government owned facilities, with their only competitor being the Admiralty yards.

The analysis of the 1907 report was conducted by the Government Factories and Workshops Committee, known more frequently as the Murray Committee, after its chair, Sir G.H. Murray, the Permanent Secretary to the Treasury. The committee was given the task of finding if the government factories could be run more efficiently and if any closures could be conducted. The committee took a holistic view to the system and then analysed every factory individually.

The copy of the report sent to the War Office for comment, as one would expect, offers more insight into the reception of the report than the report itself. The report analysis was written on 27 May by the Permanent Secretary of the War Office, Col. Sir. Edward Willis Duncan Ward, a full

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<sup>34</sup> WO 32/4293. FACTORIES: Royal Ordnance (Code 49(A)): Re-consideration of the terms of the report by the Donaldson Committee on the supply and attainments, and the selection of subordinate staff and their duties in connection with the economic results of Workshop Management, 1903.

month before public publication. According to his analysis, the most important finding of the committee was the idea of a need for a minimum permanent staff for the arsenal.<sup>35</sup> The policy was suggested with the understanding that enough work would be available to keep that minimum number efficiently employed. Striking this balance would be the most difficult of tasks at Woolwich, as the War Office was uneasy about producing commercial items in what overseeing Parliamentarians considered government subsidised factories, as their constituents could argue that the Royal Factories were undercutting the commercial competition with an unfair advantage. On the other hand, in peacetime, and especially after the recapitalization of the Royal Artillery, there simply was not enough work to go around and keep the factories with enough of a backlog to justify maintaining thousands of highly skilled employees in peacetime. Nonetheless, the civil servant accountants were well aware that there was a cost involved in losing seasoned machinists, forge masters, and draftsmen apprenticed in the most exacting, demanding, and most industrially advanced trade in the world: gunmaking. They also knew that if certain capacities were lost in either machinery or manpower it was unlikely that the capacity could be regained within a generation, if ever. In addition, the same civil servants had seen the actual figures for the amounts

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<sup>35</sup> WO 32/4734. FACTORIES: Royal Ordnance (Code 49(A)): Government and Workshops Committee; Report. Minute 70/?/2325, 27 May 1907. 2.

spent in the 1899–1902 emergency, which was well in excess of ordinary expenditure. Many, including the War Office chief auditor, Charles Harris, believed that part of the Boer War excess was in part not maintaining a proper level of peacetime ordinary expenditure before 1899. Accordingly, the largest element of this ordinary cost was skilled labour. This was accounted in the War Office stating the absolute minimum of peacetime employment at 12,000 in Woolwich, compared to the committee's 10,600.<sup>36</sup> The total amount employed at Woolwich, what that workforce did to maintain needed skills, and who would pay for it would not go away any time soon. The Murray Report would have far reaching consequences for not just Woolwich but the entire industrial base for years to come.

### Ordering policies

One of the most interesting portions of the Murray Report was a challenge to the location of the plant at Woolwich. The Government had just sold off the Birmingham Small Arms Factory to a private firm, the Birmingham Small Arms Company. Parliamentary 'concern' also aired the issue of whether the Government complex at Woolwich should also go the same way. The committee was adamant on their standings that Woolwich was ideally suited for the job, and based this on the argument that although

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<sup>36</sup> Ibid 3

labour was more expensive in London it had the invaluable benefit of providing a surge capacity needed during wartime mobilisation until trade plants that relied on unskilled labour could be converted to military production. The committee would have been acutely aware of the tenuous situation of the East End of London by this time. The financial crisis caused by the failure of the banking and investment firm Overend Gurney in 1866 forced the liquidation of most of the Thames shipbuilders, and the last major shipbuilder on the Thames, Thames Ironworks, permanently closed its doors in 1906, effectively ending a major source of income and employment for the surrounding neighbourhoods.<sup>37</sup> Yarrow Shipyard left the Thames in 1908 for Scotstoun, on the Clyde, as part of the Government sponsored reforms in armaments that created the Coventry Ordnance Works, which will be considered in more detail in the next chapter.<sup>38</sup> The Admiralty had already submitted formally its concerns during and after the Boer War as naval orders were unable to be inspected and dealt with in an overcrowded arsenal. The Admiralty wanted to completely divest itself of the arsenal as late as 1906, but financial reasons, along with new construction projects eventually maintained the status quo.<sup>39</sup>

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<sup>37</sup> A.J. Arnold. *Iron Shipbuilding on the Thames 1832-1915*. (Farnham: Ashgate Press, 2000) 75-83, 128.

<sup>38</sup> Ibid. 128

<sup>39</sup> WO 33/2960. Committee Appointed to Consider Various Questions Concerning the Methods of Inspection and Delivery of Naval Ordnance and Naval Ordnance Stores.

The shutting down of the Arsenal would have cost over 5,000 engineering jobs and would have severely distressed the London labour market. The committee proposed little in changing the status quo, primarily because they understood that the importance of the Arsenal went far beyond the immediate area or even the armaments industry.

The Royal Gun Factory and Royal Carriage Factory, Woolwich, were never designed to be able to compete on parity with the trade. The factories had two main purposes, both of which the committee found outweighed the costs of maintaining it. First, Woolwich acted as an insurance policy in time of conflict. As the factories were kept at a higher state of reserve than any commercial plant could ever be kept, the unused plant could be immediately used to start military production in a conflict whilst the trade retooled their factories for government orders. This was expected and planned to take six months. Second, as these plants produced the same products as were being purchased from the trade, the experts at Woolwich could be used to determine if pricing was fair and the quality through inspection was at a sufficient level. This second point became more important as the Government purchased technically advanced guns, especially for the Admiralty.<sup>40</sup>

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<sup>40</sup> Government Factories Workshops Committee *Report of the Government Factories Workshops Committee* (London, UK: House of Commons 1907). 7.

The Admiralty on the other hand was in the middle of a quandary. It was modernizing the fleet with new vessels of all sorts, and new guns of all sizes were needed. Unfortunately for the Admiralty, as its orders were not seen to be as urgent as those of the ‘fighting’ service during the Boer War, it was required to restrict orders. The Admiralty also believed that Woolwich was too important for the overall efficiency of the country’s industry. Not only was the site a manufacturer, but it was also the primary inspection, repair, and storage facility for all British ordnance. Although it was not as pressing for the army, the size of naval guns forced almost exclusive use of transport via barge from Woolwich to wherever new equipment was needed, primarily Portsmouth. The navy as early as 1906 requested a committee to look into this single point of failure as a likely choke point in time of war.<sup>41</sup>

### Obsolescence

The expenditure of munitions during the Boer War would have been utilized as a way of getting rid of old stock. After the introduction of quick firing, or QF, artillery starting in 1896, the British field artillery had become obsolescent. Quick firing artillery combined into one platform the

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<sup>41</sup> WO 33/2960 Committee Appointed to Consider Various Questions Concerning the Methods of Inspection and Delivery of Naval Ordnance and Naval Ordnance Stores. 8.

advances of the second industrial revolution into one deadly machine. The quick in the name came from the introduction of fixed munitions: that is both the propellant (cordite) and the projectile were sealed into a single object, thus removing loading steps. These guns also included a recuperator based on either alone or in battery with springs, hydraulic, or pneumatic assist in countering the recoil and returning quickly a gun to firing position.<sup>42</sup> The older 15-pr breech-loading guns that the British Army were equipped with in South Africa would have had no place in a front-line arsenal in a European war. The Royal Artillery saw no future with the 15-pr equipment, and set up a committee before the war was even out.

In a memorandum written in 1909 by Richard Burdon Haldane, the then Secretary of State for War, 'their (Regular Army with its Reserves) main thesis was the following: That the sole object of any military system in peace is to provide for a state of war, and the test of any peace organization must be its power... to place forces and maintain efficiently'<sup>43</sup> If this was indeed the strategy for using British troops, then the country would have to maintain an organic capability to supply such troops. Both stated objectives

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<sup>42</sup> SUPP 6/543 Special Committee on Horse and Field Artillery Equipment: Report 1. 5.

<sup>43</sup> Richard Burton Haldane, *Memorandum by the Army Council on the existing Army System and the present state of the Military Forces in the United Kingdom. Inspector-General's Report, 24th May 1909*. London, UK: House of Commons COMMAND PAPERS; ACCOUNTS AND PAPERS, Paper #Cd. 4611 1909) 2.



required an industrial base to be ready to produce on the first day of a conflict, a difficult task that would test policy makers. It would also require a permanent and persistent industrial footprint for the military, an idea that marked a change from Victorian ideals and political desires.

### **Reforms in the Services**

This industrial footprint would have to be managed by those in the government who understood the technical nature of arms procurement. The executive tasked with managing the ordnance resources (as well as many other non-warlike stores) of the army was the Master General of the Ordnance. The Master General of the Ordnance had been, since 1855, on an 'a Board consisting of-1, Secretary of State; 2, Secretary at War; 3, Master General of Ordnance; 4, Commander in Chief; 5, Inspector General of Fortifications' as well as chairing the Board of Ordnance<sup>44</sup> The Master General of the Ordnance was also in charge of the Ordnance Factories, setting standards, and overall command of much of the procurement by the government. In general, this command was headed by someone who had served earlier in their career with the Royal Regiment of Artillery, the primary customer of the goods and services under his command.

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<sup>44</sup> Hansard *HL Deb 1 Feb 1855 Series 3 Vol 156. 1248.*

The Royal Navy was somewhat more insulated from sudden public emotional swings of interest in their industrial base. As naval guns were seen as an integral and non-severable requirement of a warship, their need was more recognized as a key portion of the effectiveness of the fleet. As well, a psychology of scale must have also played some part, as the massive scale of the navy's floating structures would have awed and inspired, but also made the point that these vessels were a far cry from the commercial requirements of merchant shipowners, and would have limited the criticism of 'armchair admirals' who might have thought they knew better than the designers and users based at Whitehall.

### Sub-Contracting

The Government had a policy of ordering pre-manufactured inner 'A' tubes as well as outer 'A' tubes for larger guns from the trade for use in final manufacture at the Ordnance Factories. These tubes when mated together, the inside inserted within the outer one, created the basic artillery tube. The Government's subcontracting of raw forgings was primarily to widen the industrial base to firms who could not build whole guns, but had the ability to produce high quality finished forgings which could then be used by the Royal Gun Factory to produce the final completed guns. This was the case both for new guns and for liners for rebuilding guns. The

Army Contracts Department though felt that they were getting the worse of the deal. In 1905, it became apparent that a ‘ring’ existed among the suppliers, which cost the government more than it should have to buy forgings.<sup>45</sup> The ring had existed for several years, and during the Boer War, Messrs Taylor of Leeds went some way to breaking it by not selling their forgings at the elevated rates, which was noted by the Director of Army Contracts in his end of war report.<sup>46</sup> Taylor’s position, though, was compromised when they also conformed with the ring and increased prices in FY 1903.<sup>47</sup> Of note, a ring for gun wire had been attempted in 1901, although it was not successful.<sup>48</sup>

The Government had the ability to produce ‘A’ tube forgings for all guns in the arsenal in the period between 1900 and 1914 through the foundry at Woolwich at least in theory, but it chose not to exercise the option for guns above 6-inch in bore diameter. This was based upon a policy set forth in an 1885 pledge to steelmakers that was ‘confirmed’ in 1891 and 1900.<sup>49</sup> The Director of Army Finance, Sir G.D.A. Fleetwood Wilson, determined that the firms were indeed defrauding the government through a rigged bidding process, and determined that the Royal Gun

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<sup>45</sup> WO 254/1. Contracts Precedent Book.

<sup>46</sup> WO 395/1. Annual Reports 1873–1903. 43.

<sup>47</sup> Ibid. 27.

<sup>48</sup> Ibid.

<sup>49</sup> WO 395/2. Annual Reports 1903–1908. 16.

Factory would resort to opening up the foundry for the smaller tubes if prices did not drop. The contract solicitation for the 7.5-inch gun tubes was rescinded that year as a direct result, and as a sign that the War Office would not do business with those who they saw as not acting in good faith.<sup>50</sup> It is not clear if indeed the Royal Gun Factory foundry made billets for the 7.5s in 1905, and the first 7.5-inch guns ever made at Woolwich came in FY 1906 when one 7.5-inch Mark II was delivered, followed by twelve in FY 1907, six Mark IIs and six Mark Vs.<sup>51</sup> In FY 1908 the Government decided to try to make a 12-inch forging for the first time, which required sourcing the steel from the trade. As a whole, the Trade refused to sell the necessary raw materials to the Royal Gun Factory. After this rejection, a meeting of steelmakers was called to discuss the practices, and eventually Beardmore and Armstrongs were willing to supply the steel.<sup>52</sup>

### Naval Issues

The introduction of HMS *Dreadnought* to the world in 1906 changed permanently the ordnance industry. The new battleships required many more capital guns, (those of 12-inch bore diameter and above) than were before. These guns were more expensive to procure and maintain

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<sup>50</sup> WO 254/1. Contracts Precedent Book.

<sup>51</sup> WO 395/2. Annual Reports 1903–1908.

<sup>52</sup> WO 395/1. Annual Reports 1873–1903. 16.

than were previous generations of battleships. The relative and not absolute nature of armaments, especially for navies meant that this investment was a requirement of a world power. The issues associated with a large-gun supply chain would become normal for the remainder of the battleship era. The introduction of the all big gun battleship created challenges for all sides, but especially staffs, as the management of design in a quickly evolving world of technology required technical staffs both in and out of uniform who could get the best out of industry capability as well as managing the funding requirements for the new classes of ship required to mount them.

Amazingly though, the *Dreadnought's* guns were a product of the previous century. The massive 45 foot (at the bore) guns were constructed of carbon steel inner 'A' tubes, which had started to give the Admiralty (or more specifically the Director of Naval Ordnance) second thoughts about the high-velocity projectiles now entering service. Reports began to trickle back in 1902 reporting splits in guns or failures on yearly gunnery exercises. These guns had survived the initial proof before acceptance, which was between 23 and 27 per cent above the standard combat pressures in the breech.<sup>53</sup> This worrying setback caused the Director of Naval Ordnance, on the advice of the Master General of Ordnance and

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<sup>53</sup> ADM 256/38-41. Vols 19-22. In-letters of the Director of Naval Ordnance 1902-1905.

the Inspector of Woolwich, to implement nickel into the manufacturing process. This had already been done with several countries that had built-up naval guns, unlike the British wire wound guns, primarily the United States and Germany.

### New Materials

In January of 1903 the trade was asked about their experience and willingness to utilize nickel steel. Vickers, Elswick, T. Firth and sons, C. Cammell and Co., J. Spencer and Sons, Beardmore and Sons, Taylor, Bros. and Co, and Ince Forge all responded. With the exception of Taylor, all could supply nickel steel, although the specifications as to percentage of nickel, tensile strength and elastic limit were all over the map, and it was apparent no constant had been developed by the trade yet. Ince was removed from the list of manufacturers in FY 1904 as they were unable to produce their own steel.<sup>54</sup> Standard operating procedures that come with the maturation through the use of and experimentation with manufacture had also not been decided on. For instance, the firms could not decide if oil-hardened nickel steel was best, with Vickers even asking for ‘liberty to oil harden or not at their opinion’<sup>55</sup> Although little was

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<sup>54</sup> WO 395/2. Annual Reports 1903-1908. 16.

<sup>55</sup> Ibid 69-70

discovered, the Committee decided to order a few inner A tubes for the 6-inch Mark VII, the primary gun for all experiments, and the results would be discovered in 1904.

### Accuracy and Gun Failures

In 1904, there was a massive gunnery exercise in the Mediterranean, designed to test shell velocities for new gun tables. Obviously the calibration of guns was a very important issue for the Admiralty, and much more important than works previously written have suggested. ‘The desire to eliminate all possible causes of error is shared by every thinking artillerist’<sup>56</sup>

‘The inherent error of the gun is a factor that is commonly neglected. The inventor of a telescopic, or of a delicate orthopaedic sight, if uninstructed in its effects, would argue that if he succeeded in hitting the bull’s-eye of a target at a long range, he should be able to plant shot after shot on the same spot. The gunmaker, however, will tell him that want of accuracy in the gun will render such a thing impossible. When all possible corrections have been made there will always remain these two, viz., atmospheric conditions and the inherent error of the gun. The first can be met, as has been suggested, by accurate observation of fire; the second will

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<sup>56</sup> SUPP 6/65. Annual reports of the president. 1905. 14.

be minimised more and more as our knowledge of the construction of guns and projectiles, and propellants, increases.<sup>57</sup>

Letters were sent out to contractors in 1905 asking whether this transition from carbon to nickel steel was practicable for the supply chain. Armstrongs' response was wholeheartedly positive although Vickers challenged the specification, believing it was too stringent. No further evidence seems to be available as to whether Vickers actually conformed or not to the Government specification. Vickers' response seemed to be the start of frustrating relations between contractor and government, and this tension would put them directly into confrontation throughout the period studied.

Nonetheless, accidents with primary and secondary guns still happened. On summer exercises on 23 June 1905 *HMS Magnificent* had one of her 6' guns fail catastrophically. It appeared from the casualty report to the Master General of Ordnance that it had less to do with the material than training, as the breech was opened improperly after a misfire, but this nonetheless surely did not reassure the MGO. That same summer, hang fires from quick firing guns (likely 12-prs) on *Hyacinth* and *Irresistible* added to the difficulties and poor morale of both designers and users.<sup>58</sup>

With three guns failing, one fatally, in one summer exercise, how much

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<sup>57</sup> Ibid.

<sup>58</sup> ADM 1/7836. D.N.O. Director of Naval Ordnance In-letters 1905 Aug.- Dec.



longer would the Royal Navy stand by before forcing redesigns of their guns?

The effects of this decision created a compressed learning curve for British manufacturers with the new material, and as more production results were analysed quick advances in gun design occurred. The advances help explain the succession within a decade of battleship guns evolving from 12-inch guns to 13.5-inch and finally the 15-inch guns, all equal to or in excess of 45 calibres. (In artillery a calibre is the diameter of a projectile. The term is used to measure the length of a barrel. For example a 12-inch, 40 calibre gun would have a 40-foot long barrel from the start of the rifling.) These high shell-weight, high velocity, very high pressure guns would have been impossible under the technology of the carbon tubes. The technical issues of each of these problems will be discussed in full in chapters five and six.

The determination of the Admiralty to have more control over their orders became more pronounced in the period leading to 1914. By the 1908-1909 fiscal year, the Admiralty had for the first time allowed contractual control of warlike stores, which led to the Admiralty making more direct contact with the trade both financially and as to design. In a note declaring the design element of this new policy the 'DNO, 17.4.09, stated that the Admiralty Board had decided that, in future, designs for

naval guns would be obtained by them in direct consultation with the gun-making Firms, the design proposed for adoption being subsequently referred to the Board for the benefit of their remarks, in accordance with O.B. Instructions Paragraph 2IV. (b) The practice of referring to the Board any point in connection with paragraph 2 I. of the same instructions, would be continued.<sup>59</sup> The Admiralty was carving out more autonomy of design. This was finally allowed as the large guns that the Admiralty were designing had previously also been used by the Garrison Artillery to defend the coasts and harbours, although these defences were now for all intents and purposes finished, and the Navy became the only customer of the large guns.

The new Admiralty powers were challenged several times between 1908 and 1912, when the Chief Superintendent of Ordnance Factories and the Army Contracts Department protested to the Admiralty for not placing a 'fair share' of orders with the Ordnance Factories, as per the requirements of the Murray Committee, as well as the long-standing practice of giving the Trade and Woolwich a 'fair share'.<sup>60</sup>

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<sup>59</sup> SUPP 6/164. Annual report of the president. 1909. 413.

<sup>60</sup> WO 254/1. Contracts Precedent Book.

## **The Boer War**

From the perspective of artillery, the Boer War of 1899–1902 was to be fought as the last vestige of the 19<sup>th</sup> century. Analysts after the war, both in and out of Parliament, argued that the Royal Ordnance Factories alone could not produce enough quantitatively for the South African campaigns. This failure, both real and perceived, of the War Office became the mental image for committees through at least 1907.

The Boer War created two very different conflicts for planners depending on which side of Whitehall they worked. The War Office, which was assigned with fighting the conflict on land, had not only to manage armies on the other side of the globe, but also their suppliers at home. The Admiralty however had to keep the world's largest bureaucracy ready around the world with restricted industrial resources. The challenges of each would drive their post-war policies of how to mitigate risks and fight the next war.

## **Haldane Reforms**

The Haldane reforms in 1907 created the nucleus of both the British Expeditionary Forces (BEF) as well as the Territorial Army. Although this creation was a modernization of the combat arms strategic

formation, the reforms did almost nothing to address the demands of artillery. The Royal Artillery used equipment ordered under the Royal Artillery rearmament in March 1905 discussed in the next chapter. The older styles of guns were wheeled out of storage to the Territorial Army (TA) whilst the new BEF had been outfitted with the new 18-pr and 13-pr quick firing guns. The TA was designed to be a reorganization of several units, including the militia and the yeomanry. Therefore, it was not planned for them to need front-line artillery in their defensive role. Most striking, no field or horse artillery would be ordered from the trade from the reforms well into the next decade, with the exception of the replacement howitzers.

### Allocation

Arguably the most important government policy throughout the late Victorian and Edwardian periods was the policy of allocation. It was the Government's policy of purchasing from both the Trade and the Government Factories, based on a percentage. The percentages were based both on past experiences as well as the needs of economically keeping each stakeholder with the legitimate margins to stay open and competitive. For guns, the percentage was pegged in 1907 to be one-third of all business going to the Government Factories and two-thirds going to

the Trade. For other trades such as munitions, the percentage was much higher skewed to the Government.<sup>61</sup> Notwithstanding, the Government was not above breaking the allocation rules when it made fiscal sense. For runs that would not be economically expedient, the orders usually went to the Royal Gun Factory, so that the Government would only have to pay for one set of tooling. These percentages were based on actual weapon numbers and not on cost alone. This consistency in the ordering position theoretically allowed the private Trade to plan capital investment and to lower risk. Unfortunately, Army orders were all but consistent. In regard to field artillery, not a single 13-pr or 18-pr was ordered from the Trade after March 1906, and the last order above a single gun was made in March 1905.<sup>62</sup> Fiscal Year 1904-1905 represented the heyday of the arms industry, when 576 18-prs were ordered as well as 144 13-prs from the Trade.<sup>63</sup> This represented an expenditure of £600,584 in orders to the trade, as well as an additional £146,283 to the Ordnance Factories for additional guns. Overall, the order for the Recapitalization of the field artillery was £1,602,339.<sup>64</sup>

The only other orders for the British Army that came from the Trade consisted of the new 4.5-in quick-firing howitzers. This howitzer

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<sup>61</sup> Government Factories Workshops Committee. 7.

<sup>62</sup> WO 395/2. Annual Reports 1903-1908; WO 395/3. Annual Reports 1909-1914.

<sup>63</sup> WO 395/3. Annual Reports 1909-1914.

<sup>64</sup> WO 395/2. Annual Reports 1903-1908. 48.

was the first system designed by Coventry Ordnance Works to be accepted by H.M. Government and therefore, the company was given priority in purchase to the detriment to Armstrongs and Vickers. The first order in FY 1908 for five howitzers was placed at a relatively premium price of £430 per gun. The main replacement order was placed in FY 1910 for 64 howitzers, broken down into 32 for Coventry, and 16 for each of Vickers and Armstrongs. Interestingly, Coventry's accepted price of £354 was substantially higher than the accepted price of £248 and £250 for Vickers and Armstrongs respectively.<sup>65</sup> The latter two also proposed a price that was suspiciously close and suspiciously low, which might explain the lower numbers for each ordered by the government.

With the Trade lacking the Army orders in the post-1905 period, the Trade required that the naval orders provide work. With this, the Navy complied en masse. The relationship between the Admiralty and the War Office in regards to ordnance was probably closer than any other single aspect. This was primarily down to the Army Contracts Office placing all orders for the Admiralty until officially 1907, although records show that in practice it did so for all years with the exception of Fiscal Years 1910-1912.<sup>66</sup> Although technically the Admiralty opened their own contracting shop, they were denied by the Treasury in April 1907 for a one-year trial

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<sup>65</sup> WO 395/3. Annual Reports 1909-1914.

<sup>66</sup> Ibid; WO 395/2. Annual Reports 1903-1908.

for Admiralty staff to place their own orders, with the rationale that the duplicate work would not be in the best interests of the Government as a whole.<sup>67</sup> It was not until 27 March 1908 that the Admiralty was given permission to purchase their own warlike stores, with the 1908–09 Vote.<sup>68</sup> This permission was in all likelihood revoked due to a July 1912 Treasury/War Office decision that the Admiralty placed an unfair share of orders with the Trade to the exclusion of the Ordnance Factories.<sup>69</sup> This balance of orders dominated Admiralty/War Office high level discussions and arguments, all of which had to be submitted to the Treasury Solicitors for settlement. This is the most obvious demonstration of Treasury control over the services, although many more cases existed.

### **Changes in Business**

Although the army civil contracts staff executed ordnance contracts, the ordnance Votes for the Navy were still managed by Admiralty staff. The control over how to spend the Votes caused friction several times in the first decade of the century. In December 1901, The ‘Navy agreed to inform the W.O. (War Office) of their orders to Armstrongs & Vickers for Gun Mountings on the condition that the W.O. supply Admiralty with

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<sup>67</sup> WO 254/1. Contracts Precedent Book.

<sup>68</sup> Ibid

<sup>69</sup> Ibid

particulars of h. f. orders for garrison & siege Mtg.<sup>70</sup> The shared information on orders placed within the services maintained that competition and unnecessary price bidding was put at a minimum. As well, it represented a nascent management of the supply chain so that one company did not gain an unnecessary competitive advantage over the other. In February 1903, the services were forced by the Financial Secretary of the Treasury to share blacklists with each other, that is, of contractors who had been banned from submitting bids to the Government due to poor performance on previous contracts.<sup>71</sup> After the incorporation of Coventry Ordnance Works, the Admiralty wanted to limit their competition in guns to the Ordnance Factories, Armstrongs, and Vickers, which the Army strongly opposed. The matter could not be settled between the two services so was sent to the Treasury for decision. The Treasury responded on 2 March 1906 that the War Office policy of free competition for all those who could compete was the best approach for the Government, and forced the Admiralty to include all in the competitions.<sup>72</sup> Part of the argument put forth by the Admiralty at the time was due to a battle between the two Whitehall civil staffs on the role of patents and how this affected the choice and capacity of the industrial base. This will be

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<sup>70</sup> Ibid. 25.

<sup>71</sup> Ibid.

<sup>72</sup> Ibid. 649.



discussed in more detail in subsequent chapters. The decision showed vividly that the preferred and possibly only arbitration on policy was the Treasury, making the office a powerful player in regards to industrial policy.

### **Annual Reporting**

Most annual reports dealing with ordnance and the ‘warlike stores’, as they were secret, were channelled through the Financial Secretary to the Treasury. This position was a low-level job for a junior Minister who almost never sat in the Cabinet. The holder though had access unrivalled by any other position in the Government. The post was a clearing house for all financial matters, as well as matters that might at one time need funding. In the procurement world, that include everything. As the first person to see the reports, the Financial Secretary also had the first contact with agencies over clarification or comments. In Herbert Asquith’s Liberal Government, the position was particularly powerful, as the Chancellor of the Exchequer, David Lloyd George, was not terribly interested in the daily aspects of the job. One of his Financial Secretaries, Charles Hobhouse, quipped in his journal, ‘Lloyd George will look at no papers, and do no office work. He even refused to go to the Bank to negotiate a loan, but

went off golfing, leaving Murray and myself to deal with the matter.<sup>73</sup> In these cases the political secretaries took on power well in excess of their stated titles and party rank.

Most important of all personalities were the civil staffs who quietly but consistently carried out their duties while their political and military colleagues rotated. The civil staffs, as mentioned earlier, had statutory authority for particular tasks that made their long-term service the institution of core knowledge. These positions were mainly in finance and related tasks that were thankless for those in military service and could more easily end careers than enhance them.

## Conclusion

It is within this base that the demand for ordnance stood on in July 1914. The War Office had not placed a substantial ordnance order to the Trade in half a generation. The Admiralty continued placing orders for some of the world's largest steel castings and finished guns at an increasing rate. Policy had developed greatly from the crisis of the 1899-1902 period, with the Admiralty building ever larger strategic imperial reserves while the Army had fully re-equipped six divisions with some of the heaviest guns

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<sup>73</sup>David Edward. *Inside Asquith's Cabinet. From the Diaries of Charles Hobhouse*. (London: John Murray, 1977) 72.

that could be put into the mobile field of battle. Nonetheless, the needs of the services are just one half of the story. The demand had to be met with an industrial base that could build what the country needed. The country thus relied on both the Trade and the Royal Factories to execute the will of the people, or at least the politicians.

Demand was based upon the legal, cultural, political, and risk frameworks that existed in the United Kingdom in the Edwardian period. The experiences of South Africa were the baseline for most services in determining how they would outfit, recapitalize, build reserves, and interact with industry. The Murray Report would be the predominant single piece of policy not only for the Ordnance Factories, but by the Trade as well. The interaction of demand with supply provides the basis for the next chapter.

### **CHAPTER THREE: BRITISH GOVERNMENTAL POLICIES ON SUPPLY OF ARTILLERY, 1900-1914**

“Trade price and trade cost are different things. I do not see any reason why you should not have the prices of every trade-made article in which you are interested. Personally, I do not remember such a request coming forward to the War Office”<sup>74</sup>

-Sir Charles Harris

One cannot have arms without suppliers. No matter how strong the demand is, without those who can supply the ordered products in a timely, cost effective, and technically proficient manner, the armed forces are useless. Supplying a force can take many forms, with sources from domestic to international and state-owned to private industry and everything in between. In the case of British forces, the strategy of procurement was decided through the policies set forth in the Parliamentary debates seen in the previous section, paired with necessity, international need, and opportunity.

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<sup>74</sup> WO 32/4293. Mr Charles Harris. Report of the Committee appointed to consider the supply and attainments, and the selection of the subordinate staff of the Ordnance Factories. 96.

This chapter will discuss the governmental and industrial factors influencing supply from the armaments industry in order to understand what capacities and capabilities the government buyers had to work with, and what drove designs for everything from post-*Dreadnought* battleships to field artillery. The chapter starts with an historical overview of the trade followed by an in-depth analysis of manufacturers from 1900 to 1914 from the perspectives of management and capacity. The role of exports and government policy will also be analysed. The largest sections of the chapter deal with technology and how it affected armaments. All of this will illuminate the capacity and history of Britain's ordnance trade before July 1914.

### **Historical Supply Chain**

From 1862 until 1888, the British Government did not purchase a single service gun from the Trade as a matter of policy.<sup>75</sup> The Royal Factories, based at Woolwich, in south-east London produced the entirety of the Government's orders. It was not until technology advanced, along with persistent lobbying from the engineering industry, that the Government Factories lost their monopoly. From 1888 until the turn of the century, the new breech-loading guns entered the Government's

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<sup>75</sup> J.D. Scott. *Vickers: a History*. (London: Weidenfeld and Nicolson, 1962) 40.

armouries and vessels and changed armaments for Western Europe and the world.

The post-1888 relationship with industry is most important to this thesis. The Government maintained a close relationship with suppliers. This was a product of circumstance as much as anything. The requirements in plant outlay demanded massive investment in specialized machinery that was not commercially viable for any purpose or customer other than government orders. Throughout this period the relationship between customer and supplier was complementary, and not one of dependence, as the Government Factories had the necessary capacity to execute all the needs of the services and were able to produce all that the trade could. As long as the state maintained the element of control, a 'military-industrial complex' could not arise as the state remained the key factor.

Unlike most industries and plants that produced warlike stores, gun making required an exceptionally large proportion of high-skilled labour. The Murray Report in 1907 mentioned this several times as a primary reason why the Royal Gun Factory was unable to find much labour economy in peace due to the skilled and valuable people who worked there. Ordnance production required large numbers of engineers, or skilled machinists. These workers, who were usually part of the unionized

labour force, especially in the Trade, were the embodiment of years of artisanship in the United Kingdom.

The supply chain of ordnance was as evenly spread out as could be planned. From the Thames, to the River Clyde; from the east coast to the west coast, and even the inland heart of steel making, located at Sheffield, each location gave particular advantages and disadvantages, including labour, raw materials, and proximity to political and economic power. Each also represented the style of business that their particular region encapsulated.

In addition to the highly skilled labour force, a recurring theme of the producers of armaments was the vertically-integrated nature of the industry in which they operated. The producers were some of the largest industrial companies in the country and had the ability to cast and forge all the necessary parts in house, without having to go to second-tier suppliers for smaller components such as inner barrel tubes, although from time to time some did when it fitted business needs. The very nature of ordnance required investment in plant not required for any commercial need. For instance, plants had to have the ability to move barrels in excess of 50 tonnes to simply manufacture, requiring everything to be titanic in scale from cranes to lathes to presses.

## The Mature Trade

Sir W. G. Armstrong Whitworth & Co. (Ltd.) was the worldwide originator of all-steel artillery, and was arguably the greatest engineering company in the world by 1900. Armstrongs, as the firm were known on a daily basis, was based in Elswick, near Newcastle upon Tyne. In technical documents, the name of Elswick was also used, especially by the Ordnance Committee, to differentiate from their offices and plant at Openshaw, Manchester. The Manchester offices were assumed when Armstrongs purchased Whitworth, a long-term competitor. The majority of the guns produced by Armstrongs were produced at the Elswick site, although the Openshaw facilities were able to also produce much of the Armstrongs line of ordnance. The firm could design and build everything in the British arsenal during the first decade of the 20<sup>th</sup> century. Sir W.G. Armstrong had modernized the Royal Arsenal from 1859-1863 when he was the Superintendent of the Royal Gun Factory, Woolwich. His had a large presence in shipbuilding for the Admiralty and through their several plants around Newcastle were able to build an industrial empire that continued after the death of its founder in 1887. The company was the primary shipbuilder on the North Sea coast for Admiralty orders, and the fortunes



of the company were greatly influenced by the scale and regularity of orders coming from Whitehall.<sup>76</sup>

Armstrong's had been the primary ordnance designer outside of Woolwich from the 1880s through the start of the 20<sup>th</sup> century, although this primacy was fading after the Boer War. No evidence for this fall from grace is in the records, and their quality of work was certainly the best in the trade, if rejection rates alone are looked at.<sup>77</sup> Armstrong's also led the transition to nickel steel, which will be discussed more fully in the next chapter. Armstrong's' capacity and quality ensured the company as a world leader throughout the period. By examining their export orders, Armstrong's supplied many rising and established world powers around the globe who did not have the industrial capacity to build their own weapons of war. After 1899, the firm was led by Sir Andrew Noble, a fellow of the Royal Society, the premier club for scientifically minded men in Victorian England.

Vickers (Ltd.) was also a leading design and manufacturing house for Government contracts, as well as the British leader in arms exports to foreign states. Located in Barrow-in-Furness, (today in Cumbria) their first business venture into the armaments sector was not in artillery, but in

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<sup>76</sup> SUPP 5/1036. List of senior staff 1888-1926 and historical enquiries.

<sup>77</sup> ADM 256/43. Vol 24. 1906-1907 Inspector of Steel tested forgings at Sheffield, Newcastle, and Manchester.

machine guns. Vickers first paired with the American inventor Hiram Maxim in 1884 to produce the weapons in England.<sup>78</sup> The originally South Yorkshire and later Cumbrian company in the 1880s and 1890s created and furthered the original wire-wound gun designs that would become the dominant construction technique for British ordnance. Vickers, like Armstrong, were heavily engaged with shipbuilding for the Admiralty and helped to dominate the 1890s armour market that drove further experimental metallurgical work with newly possible blends that would make it into their gun designs later. Their River Don Plant in Sheffield, Yorkshire, provided the guns for both the domestic and, importantly for the company, foreign markets.<sup>79</sup>

The Vickers staff was dominated by James Dawson, a former Lieutenant of the Royal Navy who had been picked by Vickers from the staff of the Royal Gun Factory. Dawson had technical knowledge of the latest research and design being conducted by the Government as well as important pricing data. His intelligence would be the driving factor for the company for the next 20 years. With Dawson, Vickers branched out into designs for all sizes of guns, including designing all the big-guns for the Admiralty in the second decade of the century. Vickers, like Armstrongs

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<sup>78</sup> Clive Trebilcock. *The Vickers Brothers: Armaments and Enterprise, 1877-1914*. (London : Europa, 1977) 38.

<sup>79</sup> *Ibid*, 83.

also built ships out of their Cumbria plant, although unlike their Elswick competition, they did little outside of armaments, focusing on defence engineering only. This business model was one that the company flourished in, but it also forced them to be much more aggressive with the Government than Armstrongs, a trait that would appear again and again. Vickers had similar capacity in sheer size to Armstrongs, and could make anything needed in house, and if they did not, they would expand, assuming a business model of tailor to the Government's needs or die.

Several other works based around Sheffield produced parts of ordnance for the primary manufacturers. Firms such as Cammell Laird from their Cyclops Works, Sheffield, John Brown at Atlas Works, and Hadfields from Hecla Works, as well as other steel manufacturers were crucial to the overall industry, although because they were still primarily commercial firms, providing smaller components, they were both less represented in governmental correspondence and not represented in design competitions. These firms are almost wholly absent from the historiography. They were also rarely mentioned in contracts as they acted as subcontractors of larger orders and, except on rare occasions, these contracts were not considered important to record. Unfortunately their study falls outside of the general scope of this thesis, although it is an area that needs more study by historians.

## The Government

The Royal Factories consisted of a group of Government owned industries engaged in producing a wide variety of goods. The works were primarily located at Woolwich, in southeast London, although other parts of the group included the Royal Small Arms Factory at Enfield, the Royal Gunpowder Factory works at Waltham Abbey, and even the Royal Army Clothing Factory at Pimlico, London and the Post Office Factories. The Woolwich works included the Royal Gun Factory, the Royal Carriage Factory, the shell filling factory and Royal Laboratory. The running of this complex enterprise fell to the War Office, finely balancing a myriad of political, fiscal, and military decisions as to its daily operation. All factories operated under a joint mandate, with all ordnance factories producing goods for both the Royal Navy and British Army. Both services also therefore helped fund the factories through their annual Votes. Each of the factories ran effectively as a semi-independent organization, with each factory getting its own budget votes for its operation, through the larger service budgets. For the scope of this study, we are only interested in the Royal Gun Factory.

The Royal Gun Factory, Woolwich was the primary Government site for skilled engineering staff. The staff requirements for building guns

was very different from the other parts of the Woolwich complex as it was the only factory to use almost exclusively skilled labour. Woolwich utilized this skilled labour force as the primary means of maintaining accurate price estimations, as it was the only site in the whole of the government that had built artillery types that were being tendered for bidding in the trade. Woolwich also maintained the inspectors who were in charge of accepting or rejecting any work submitted under contract from the Trade. This extremely important task would have been much more difficult to do without understanding all of the ins and outs of the systems that were being submitted.

In British India, the Indian-Government owned Cossipore Manufacture commenced working on quick-firing guns soon after the field artillery specification was created in 1905. It was hoped that the Gun factory at Cossipore, Calcutta would be able to supply 18-pr. and 13-pr. guns during 1906–1907<sup>80</sup> Yet by May of 1907, it was reported that difficulties had been met at Cossipore in producing the new guns. India's reliance on the Cossipore Gun Factory 'for a local supply of guns, has not

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<sup>80</sup> East India (financial statement). *Return to an address of the Honourable the House of Commons, dated 7 May 1906;--for, 'return of the Indian financial statement for 1906-7, and of the proceedings of the legislative council of the Governor-General thereon.'* Vol. LXXXI. (London, UK: House of Commons, 1906) 99.

worked up to the anticipated output.<sup>81</sup> Part of this struggle might have to do with the factory not being electrified until the 1911–1912 fiscal year at a cost of £4000 equivalent.<sup>82</sup> The problem with the India plants was that there was insufficient skilled labour to perform tasks. For instance, the Royal Carriage Factory in Jubbulpore (now Jabalpur) was estimated to be able to work at only 10 per cent efficiency compared to a European factory, although the quality was of a European equivalent.<sup>83</sup> As with most industrial issues, the underlying issues were more complex than the story on the surface. India had a performing trade school system, although the system demonstrated how difficult it was to create a skilled labour workforce that was able to do fine engineering work. The reports from India also show that the already limited workforce appeared to be comprised exclusively of converted Christians. This further narrowing on apparently ideological concerns hindered the usefulness of the imperial factories to aid in time of crisis or shock to the home industries. It was not therefore a surprise to find the Annual Reports of the Ordnance Factories,

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<sup>81</sup> East India (financial statement). *Return to an address of the Honourable the House of Commons, dated 2 May 1907;--for, 'return of the Indian financial statement for 1907-8, and of the proceedings of the legislative council of the Governor-General thereon.'* (London, UK: House of Commons, 1907) 97.

<sup>82</sup> East India (financial statement and budget). *Return to an address of the Honourable the House of Commons, dated 10 May 1911;--for, 'return of the Indian financial statement and budget for 1911-12, and of the discussions thereon in the Legislative Council of the Governor-General.'* (London, UK: House of Commons, 1911) 248.

<sup>83</sup> East India (Industrial Commission, 1916 18). *Minutes of evidence taken before the Indian Industrial Commission, 1916-18. Vol. I.--Delhi, United Provinces, and Bihar and Orissa.* (London, UK: House of Commons, 1919) 31.

especially the Royal Gun Factory, Woolwich Arsenal, producing guns of all sizes that were billed to the Indian service. This relationship and especially the important but understudied learning process of transfer of officers between India and Woolwich helped develop India's skilled manufacturing industry with British expertise, but also provided London with ideas borne out of necessity on the rugged Indian frontier.

### Repair Work

Woolwich also played an important yet underreported role of primary repairer of all ordnance both for afloat and afield. The 1907 Murray Committee described it as 'incontestable that repairs of all kinds necessitated by the wear and tear of the service, from a battleship to a rifle, are more economically effected by Government than by private contract. The amount of repair required in a given case can scarcely ever be gauged with any degree of accuracy beforehand, nor is it easy to devise any effective means of checking the items of the labour bill in the case of repairs done under contract'<sup>84</sup> The role also extended to the task of relining of all ordnance. As guns wore out, their accuracy was greatly diminished. Instead of the guns being scrapping, British ordnance of all types was

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<sup>84</sup> Government Factories Workshops Committee *Report of the Government Factories Workshops Committee* (London, UK: House of Commons 1907.6-7.

designed to be rebuilt or relined to restore accuracy. This process included boring out the original rifling and inserting into the barrel a new sleeve or ‘A’ tube with new rifling that mimicked the original specification. This process saved time and money in comparison to building new guns. The Royal Gun Factory served as the primary shop for relining for all services well into the 20<sup>th</sup> century. After an experience with 12-pound breech loading guns in South Africa, the Director General of Ordnance stated ‘that, when possible, guns would be brought home, for repair to the approved designs.’<sup>85</sup> This would remain the policy of the government in peace and war throughout the remainder of the period under study.

The other reason that Woolwich preferred to do the work in house other than for fiscal reasons, was to understand better the underlying problem of why the piece failed or how different pieces wore out at different rates. This was done primarily by the Chief Superintendent, the Director, Royal Gun Factory, and the Chief Inspector, Woolwich, with the technical assistance of the Royal Laboratories. This process allowed for operational research to be incorporated back into the production cycle, with minor modifications occurring frequently after guns were rebuilt to bring them up the most recent drawings which incorporated these improvements. The learning and design provided by Woolwich was a large

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<sup>85</sup> SUPP 6/60 Annual reports of the president. 1901. 67.



part of what made the Trade so successful in producing guns that were long wearing, accurate, and most importantly, safe to the user community.

Unlike the trade, the Arsenal had to follow Treasury accounting rules. For instance, the Chief Superintendent could not expend over £100 without the express permission of the Financial Secretary. This was exposed in 1903 as a weakness that would have to immediately be raised at the declaration of war.<sup>86</sup>

Woolwich like all government factories, tended to have a different talent pool, especially in regard to managers. It was made known by Charles Harris in 1902 that the Royal Factories tended to promote personnel who possessed ‘inventive genius’ to management as a way of rewarding intellectual excellence. This was not the norm in the trade as a whole, and this gave both benefits and weaknesses to Woolwich. The management of the arsenal might not be as economical, but the quality of problem solving might be greater.<sup>87</sup>

Woolwich was also hamstrung by governmental staffing rules that were not a problem of the trade. The bureaucratic staffs, and especially the clerks and senior civil staffs, were becoming increasingly difficult to keep.

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<sup>86</sup> ADM 1/7686. D.N.O. Director of Naval Ordnance In-letters 1903 Mar. – Apr.

<sup>87</sup> WO 32/4293. FACTORIES: Royal Ordnance (Code 49(A)): Re-consideration of the terms of the report by the Donaldson Committee on the supply and attainments, and the selection of subordinate staff and their duties in connection with the economic results of Workshop Management, 1903. 94.

Those who were willing to join the civil service were progressively more unwilling to work for the Ordnance Factories. Pay had not increased in over a decade by 1902, while at the same time pay and benefits had increased for those working a few miles away at the War Office. This was especially true for those who bore the brunt of the day-to-day work of running the complex, the Second Class Clerks, of whom there were ten allotted for the whole of the Ordnance Factories, including Enfield, Birmingham, and Waltham Abbey.<sup>88</sup> Changes in the Civil Service as a whole had left Woolwich behind, and were compounded by inaction on the 1898 report written by Mr De La Bere, then the Accountant General of the Army. The Committee proposed an increase of £1,125 over the current salaries to gain and maintain the best recruits.<sup>89</sup> In comparison, the contemporary cost for a single 6-inch Mark VII gun without breech or fittings was £1,645.<sup>90</sup> The funding request, as well as permission to reorganize the staff, was approved by the Treasury in January of the next year, about a month after its submission. It also approved the transfer of one of the newly appointed senior clerks from the War Office to

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<sup>88</sup> WO 32/9042 9042 FACTORIES: Royal Ordnance (Code 49(A)): Report of Ward Committee on clerical staff. 1.

<sup>89</sup> Ibid 3

<sup>90</sup> WO 395/1. Annual Reports 1873–1903.

Woolwich, which was a somewhat unusual move that is unseen at any other point in the period under study.<sup>91</sup>

The design branch of Woolwich was arguably the greatest, of all the manufacturers in the United Kingdom due to its sheer depth of resources as well as the ability to do research that was for non-profit based purposes. Woolwich had access to the whole process, from platform development through results of destructive and other testing, as well as the pricing data and other confidential information that no other manufacturer possessed.

### The New Trade

The creation of Coventry Ordnance Works in 1905 was a direct response to a lack of competition between Vickers and Armstrong. The Company was formed as a Joint Stock Company representing the companies of John Brown with a one half share, Cammell Laird with a one quarter share and Fairfield Shipbuilding and Engineering Company while the final one quarter share to create a vertically integrated supply chain.<sup>92</sup>

The company made its contracting debut on the massive rearmament

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<sup>91</sup> WO 32/9043 FACTORIES: Royal Ordnance (Code 49(A)): Implementation of recommendations of Ward Committee on new establishment for clerical staff Recommendations and opinions concerning various members of staff.

<sup>92</sup> Joint stock companies. *Return of the companies registered during the year ended the 31st day of December 1905 which filed a prospectus, and to which certificates to commence business have been granted; &c., &c.* (London, UK: House of Commons, 1906), 32.; Kenneth Warren *Steel, Ships, and Merr. Cammell Laird. 1824-1993* (Liverpool: Liverpool University Press, 1998) 124, 139.

order for the Royal Field and Horse Artillery in March 1905, as well as becoming a provider for naval guns. The Government was so pressed to place the order due to the end of the fiscal year, that it was actually placed with Cammell Laird. According to records of orders placed, this policy continued through the first years of the Company, with Coventry Ordnance not receiving an award in their name until August 1907.<sup>93</sup> Regardless, it does not appear that they were allowed by the Admiralty to enter the armaments business.<sup>94</sup> The company plant utilised the Coventry works purchased from Mulliner-Wigley which was rebuilt after the purchase with state of the art machinery to produce massive guns and gun mountings for the burgeoning Royal Navy. The company built their first order as part of the Field and Horse artillery rearmament, although quickly they were given contracts for 4-inch and 4.7-inch guns. It was said by the Director of Naval Ordnance in January 1906 that most of the equipment was shipped over from America, the company utilized heavily electrical and pneumatic tools, and it was showing promise on the orders that it had been given.<sup>95</sup> Although this plant was supposed to be state of the art, it appears that at least for the first few years, the Cammell Laird-owned

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<sup>93</sup> WO. 395/3 *Supplement to the Report of the Director of Army Contracts for the year ending 31<sup>st</sup> March, 1908*. 51.

<sup>94</sup> Hansard *HC Deb 29 March 1909 Series 5 Vol 3* Question asked by Viscount Castlereigh. 39.

<sup>95</sup> ADM 1/7897. Director of Naval Ordnance In-letters 1906 Feb. 30 Jan 1906 report from DNO.

Grimesthorpe plant in Sheffield was the primary site for manufacture of armaments and armour. It became an issue that appeared in the House of Commons debates in 1909 when it became known that the RN had not placed a single order for gun mountings until the 1909 Naval Expenditure. Their first order equipped HMS *Colossus*.<sup>96</sup>

The Parliamentary debates showed that the Commons did not either know of or take into account the reason for the Admiralty's mounting policy. In 1903 the Admiralty, with the permission of the Director of Ordnance and Ordnance Committee, forwarded an agreement to Armstrongs and Vickers to mutually allow gun mountings to be produced without charge of royalties to the two trade members and Woolwich. This agreement saved the government thousands of Pounds Sterling a year as well as allowing free flow of the best designs irrespective of royalty amount. With this, the agreement clearly made the link that any other manufacturer would have to pay for the amount of the royalty as well as jigs and other works to produce them. Interestingly, the agreement seems to have been exclusively for gun mountings themselves, which in the form of permanent mountings, the Ordnance Factories never produced, and it was in direct contradiction to talks of patents in the documents.<sup>97</sup>

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<sup>96</sup> Hansard *HC Deb 24 July 1912 Series 5 Vol 21* Question asked by Mr. Borgyne to Mr Churchill 1215.

<sup>97</sup> ADM 1/7897. Director of Naval Ordnance In-letters 1906.

This was justified by Armstrong's as new manufacturers had not paid for the experimentation of years of work to perfect designs and therefore it would be an unfair competitive advantage to let them enter.<sup>98</sup> Although this would have limited competition, there was no other manufacturer (other than Vickers-controlled Beardmore) that could have produced gun mountings competitively in Britain.

In 1905 the largest of Vickers patents came up for expiry: the Wellin Screw Breech. The Government had paid substantial royalties to Vickers including £180 per 12-inch gun, £150 per 9.2-inch, £ 80 per 7.5 inch, £50 per 6-inch, and £40 per 5-inch gun for a total of £18,280 in 1903/1904 alone.<sup>99</sup> The breech even with the royalties did not perform as wanted, and had the problem of sticking when opening or closing. In addition, between 1900 and 1903 Vickers paid £9,772 to Armstrongs in royalties for guns produced by Vickers, which was passed along to the government.<sup>100</sup> At that point the Government led by the Director of Naval Ordnance believed a similar plan could be put into place to control capacity and continue with what was essentially a preferred supplier system. This plan would be vigorously put down by the War Office and the Treasury, and set up a half decade of control of policy by one branch, much to the consternation of

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<sup>98</sup> ADM 256/42. Vol 23. 663-664.

<sup>99</sup> ADM 1/7897. Director of Naval Ordnance In-letters 1906.

<sup>100</sup> Ibid.

the Admiralty. The primary reason for this was the much larger contract for field guns that the War Office wanted competition with. The necessary evil of speaking as a single Government to suppliers would become a hallmark of the British way of procuring war material.

To the duopoly of manufacturers Vickers and Armstrong, Coventry seemed to be a warning shot. Coventry had the same manufacturing capacity, and, after a few years, had the same contract bidding privileges as the heavily entrenched incumbents of the trade. Although it increased the overall capacity of the trade and therefore, Great Britain, there is no indication from the government that this served any purpose other than increasing competition within the Trade as a way to drive down prices in the peacetime bidding cycle. It does not appear that the decision had any real wartime purpose, unlike the policies augmented towards Woolwich. Furthermore, because of the lack of army orders after 1905 and the close management of naval orders, as well as the quickly evolving technological changes in naval guns, there is little or no proof that price was affected in any way by the introduction of Coventry (with the sole exception of the Coventry designed 4.5-in howitzer) in field pieces at least. As a note this statement is probably not valid for naval gun mounts, although they are outside the scope of this study.

There is no doubt that Coventry increased the overall capacity of ordnance in Britain. New and improved forgings were, by March 1913, coming out of both Coventry and Openshaw, the Armstrongs plant for the first time engaging in naval orders on a large scale. This was shown in the latter with much improved 13.5-inch inner 'A' tubes. Coventry, in a desire to not be left behind as naval guns grew, had rebuilt their furnace to work the 13.5-inch Mark V naval guns by enlarging it, which gave satisfactory results.<sup>101</sup>

The final player in the ordnance field rose from the second-tier forgings suppliers to becoming a full-fledged naval ordnance producer. William Beardmore (Ltd.) had been producing gun forgings at the company's Parkhead, Scotland forge for many years and was one of the suppliers of large forgings to Woolwich as well as Vickers. Vickers in reality was much more than a customer of Beardmore. In 1902, Vickers purchased fifty per cent of the ordinary shares of the Glasgow company. Supposedly the purchase came with the understanding that Beardmore would not enter the armaments industry, and remain a leader of the armour trade.<sup>102</sup> The relationship created what essentially was a Vickers proxy, and the two companies spoke in tandem against any deviation in policy that was not in Vickers best interest. By 1908, Beardmore was still

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<sup>101</sup> SUPP 6/168. Annual report of the president. 1913. 312.

<sup>102</sup> JD Scott. *Vickers*. 49.



not a competent design house. They requested to be placed on the List of Manufacturers of Ordnance, and were asked to design a 4-inch 50 calibre gun, which they did by coping a Vickers design perfectly, and even then the design had only been produced once, with the preferred design for the mark being an Elswick pattern. One order was given to see if they could produce a gun to design.<sup>103</sup>

The company received their first complete gun contract in FY 1914 for the new B.L. 15-inch naval guns for the *Queen Elizabeth* class battleships.<sup>104</sup> With this order, Beardmore represented a very different theory of supply chain diversification than what the Government had pursued a decade earlier with Coventry Ordnance. Beardmore was not just an ordnance maker. Shipbuilding constituted their primary business and the Clyde shipbuilding business had never been better by 1910. They had received several orders from the Admiralty for capital ships and so understood well the processes and inspection required to maintain work with the Government.

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<sup>103</sup> SUPP 6/163 Annual report of the president. 1908. 13.

<sup>104</sup> WO 395/3. Annual Reports 1909-1914.

## Labour

Organized labour became a rising issue in the first decade of the century. In 1904 the subject of preference to union shops was lobbied in London's governmental circles.<sup>105</sup> The official tack taken by the government was that any labour would have an equal chance of getting contracts. Therefore, union shops and non-union shops would both have the ability to compete, and would be held on parity. It was a win-win for all, although in reality ordnance production was limited to a few locations and nearly every shop utilized unionized labour.

The Royal Gun Factory, as with all of the 6,000,000 square feet of factory floor Woolwich complex, ran on an 8 hour system, working 'from 8 a.m. to 1 p.m., and again from 2 p.m. to 5:40 p.m. daily, except Saturdays, when work ceases at 12:40 p.m.'<sup>106</sup> The factory's labour, being in London, came under parliamentary scrutiny in 1908. It had come to the attention of politicians that the workforce had substantial benefits, and might be paid too much. The committee analysed if Woolwich employees were being overcompensated for their work in relation to those in the Trade elsewhere in London. It emerged that Woolwich workers' base salary was actually well below the standard for the trade in the area.

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<sup>105</sup> WO 254/1 General Note Book 485.

<sup>106</sup> SUPP 5/1036. List of senior staff 1888-1926 and historical enquiries.

Employees were paid a base weekly wage of 37 shillings, 6 pence for 48-hour work weeks whilst the trade workers were paid 40 shillings for the same time, although the trade employees worked a 54 hour work week.<sup>107</sup> This base wage was supplemented by piecemeal wages. In looking into the fairness and full compensation of the workers, the Chief Superintendent of Ordnance Factories, Sir Hay Frederick Donaldson, found that of 8,123 workers, only 112 did not earn their full rate in the last quarter. He also found that the plurality (45) of this figure were lads who did not have work because there was not enough work, and in regards to men, the leading cause (34) were of men who waited for work without leaving the shops. These were not particular to the factories as an exemption, but were the norm for the industry as a whole. Donaldson also found that the rates themselves were fair, with 2,309 rates being reviewed over the same time period, which lowered 1,078 of them, mainly due to improvements in technique. Interestingly, any employee could challenge the calculation, and a foreman could modify the rate if he saw it as not being correct.

This was addressed again for the Government factories a few years later, when it was proposed to bring the factories at Waltham Abbey and Enfield on par with Woolwich rates, although only unskilled base wages

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<sup>107</sup> WO 32/7063 CIVIL STAFFS (OUTSTATIONS): General (Code 47(A)): Pay and conditions of service in Ordnance Factories. Deputation of Amalgamated Society of Engineers to War Office. 2.

were looked at by the group. The base pay of 24 shillings was one more shilling than the suburban factories.<sup>108</sup> From the Donaldson Commission above, it appears that unskilled labour was not employed in the Royal Gun Factory in particular, as this lower salary was not accounted for in the reports. The difference between unskilled and skilled labour is an interesting point to look at. The difference of over 50% between unskilled labourers and the skilled piecework tradesmen show that these were not simply replaceable workmen that the Royal Gun Factory employed.

This direct connection between the work done and remuneration was not only the most efficient and fair procedure, but also kept the workforce content, and certainly had the possibility to affect quality, the most important element in arsenal work. The government's position was that employees should be compensated on their ability to produce, and the more efficient employees should be rewarded for doing their best work. What might be the biggest 'cost' to the way in which Woolwich compensated its employees was that the arsenal did not discharge employees at the first sign of downturn in work, unlike the trade. The employees at Woolwich had a more stable future, which, especially at the Gun Factory, was important in keeping skilled labour employed by the

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<sup>108</sup> WO 32/9275 FACTORIES: Royal Ordnance (Code 49(A)): Report of Fair Wages Advisory Committee on minimum wage for workers at Admiralty and War Office establishments. Deputation from United Government Workers Federation.

Government. This was key in the ability and capacity of Woolwich to compete with the trade, but also to retain the critical skills ordnance required.<sup>109</sup>

In regards to trade unions, the Amalgamated Society of Engineers was the strongest and largest of the labour associations within the skilled work force. Woolwich, although technically not a union shop, had union members on the shop floor. They appeared to act as a sort of bargaining unit, although were not effective as such before the war. Their petitions for a raise in 1908 were flatly rejected by Donaldson as not being in the best interests of the government, or London industry as a whole.<sup>110</sup> The issue of unions was never a worrying problem, as the Amalgamated Society of Engineers had a good working relationship with the employers. This was probably a product of their members being relatively well paid as well as the membership in general being more educated and trained, and therefore older. This was a different experience from in some of the other industries around the country at the time, especially shipbuilding.

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<sup>109</sup> WO 32/7063. CIVIL STAFFS (OUTSTATIONS). 4.

<sup>110</sup> Ibid. 31.

## Gun Design and Workforce Skill

The skill of the British engineer had much to do with the final design, execution, and use of guns. The seemingly simple task of wiring a gun was in reality about as complex as any engineering project of its day. It required immense skill that we would struggle with it today even with the aid of computers. Wire was an integral part of the design of British guns, and was the primary safety design feature. It allowed a margin in both gun pressure and a bit of lateral flex that did not interfere with the accuracy of the gun. Wire, due to the ‘mechanical work expended on it’, had more ‘elasticity, tenacity, and ductility’ than the regular gun steel that it was wound around.<sup>111</sup> Wiring a gun though was not a simple task. First, companies had to either source or make high quality carbon steel wire that was of sufficient quality to allow a force in excess of 50 tons of pressure per square inch to be imparted on it, as well as being flexible enough to be allowed to wind around a gun tube precisely so that it lay with no gap between strands. What made a difficult job almost impossible was the design requirement that each layer that was placed above the previous one had not to exceed the pressure of that laid down before it. This meant that, as the diameter of the barrel grew as it spun on its gun lathe, the engineer

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<sup>111</sup> ADM 186/220. Manual of Gunnery for HM Fleet. 43

had to calculate the increased distance travelled per rotation, and adjust the feed so that it sped up at a rate that was proportional to the new diameter. If the operator kept the same feed rate, the wire would increase the tension due to it being pulled faster. The tension, the gun's diameter, and lateral movements of the wire all had to be taken into account. In 1905 this difficult task was made even more tedious with the introduction of a tapered breech section of the tube. This was in response to the needs of both longer barrel life and increased ease in the relining process. The tapered tube meant that tension now would have to be watched and changed as each layer of wire went on, a departure when older designs had the same tension throughout each layer of the installation.

The tapered approach to wired gunmaking was the height of skill for the British engineer. Skills in accuracy, precision, and manufacturing consistency made the British wire wound gun an efficient tool in war, but also represented in a microcosm why issues of capacity, labour, and quality supply chains were so important in British national security. These were skills that could not simply be created overnight, and the main manufacturers had spent almost two decades by 1914 building the capacity. Many skills in the ordnance trade could be quickly learned, and capacity could easily be converted, such as shell production. The truly skilled work

force in heavy ordnance production would not be replaceable without considerable time, resources, and investment.

### **Management**

The blue collar workforce was not the only element of the Trade that greatly affected the abilities of the industry as a whole. The directors of the trade firms were extremely important not only for the management of production, but also as the face of the company to the customer. From a management perspective, ordnance posed a radically different means of business from other portions of the armaments trade and an even more radical departure from the steel industry as a whole. This was especially the case in the time period of study. Arguably, the period from 1900–1914 for gun making was completely unlike any other industrial evolution that had been seen before. The introduction of new metals and alloys required massive investment in metallurgy, both in staff and capital infrastructure. The introduction of longer, heavier, and more complex naval guns required ever increasing investment in plant capital, especially in regards to lathes, cranes, and forges. The introduction of nickel steel also meant that tooling and techniques that worked acceptably with carbon steel forgings might not work with the much tougher and harder alloys. The industry effectively had to reinvent itself constantly to



have a chance of landing the next contract for the increasing barrel weight of ordnance ordered by the Admiralty. It is with this background that the management of the trade must be considered.

As the youngest player in the field, Coventry had the most to prove to the Government to pry the duopoly away from the north. Herbert Mulliner became the first director of the corporation although his relationship with the Government quickly soured. As the corporation's orders were less than was desired, the Board replaced him in 1909. His replacement in November 1909 was the newly retired Rear Admiral Reginald Bacon.<sup>112</sup> Bacon was hired to rebuild the relationship with the Admiralty. As Director of Naval Ordnance, Bacon oversaw the design of the post-Dreadnought capital ship armament. Coventry had so much hope in him that they were willing to pay £7,000 annually, or put another way, £2,000 more than the Prime Minister's contemporary pay.

Armstrong Whitworth also had acquired several executive directors with military and civil pedigrees. Sir Percy Girouard joined the Elswick Plant's payroll in 1912 after a distinguished career working as the Director of Imperial Military Railways. In the same year, Sir George Murray also joined the payroll. Murray had led from the Treasury the reforms and policies set forth in the Government Factories and Workshops Committee

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<sup>112</sup> Kenneth Warren *Steel, Ships, and Men: Cammell Laird, 1824-1993*, 145-147.

report, commonly named the Murray Report. Both of these acquisitions advanced the strategic views of the board as well as bringing in extensive contacts in the Treasury and Army.<sup>113</sup> This revolving door, especially at Armstrongs, might seem suspicious, given that both of these men were well connected, although they had already achieved long careers and had reached the end of any chance of promotion. Murray would have been particularly unusual as he was the longstanding permanent secretary, and, knew the budgetary process better than anybody else, as well as the strategic needs of industry for the Government.

## Exports

The role of exports in the Edwardian period played a not insubstantial role in the gunmaking business. Vickers and Armstrongs dominated the overseas market, competing for Asian, Eastern European, and South American contracts with the likes of Germany's Krupp and Ehrhardt, France's Schneider et Cie, and America's Bethlehem Steel and Midvale Steel. Being on the list of approved government vendors could make all the difference between receiving a contract or not. The certification by the home government seemed to be a prerequisite for the developing world to place orders. The Government also seems to have had

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<sup>113</sup> J.D. Scott. *Vickers: a History*. 92.

no problem subtly promoting British industries. For instance, in 1905 a Naval, Shipping, and Fisheries exhibition was held at Earl's Court, in which it requested that the navy submit current equipment.<sup>114</sup> The navy seems to have almost always complied with requests such as these if the available spare tubes were available.

In regards to guns, the vast majority of guns by value sold to external customers came from the naval gun side of operations. In the Vickers drawing collection at the National Maritime Museum, Woolwich, there are several copies of drawings for export guns. These guns were made for places like Japan and Turkey, but as well for many South American navies.<sup>115</sup> Not all of the drawings were actually finished in steel, but certainly the company had a thriving gun design and manufacturing department, as well as a world-class marketing department. The Royal Navy by policy ignored claims of performance from the trade published in trade journals for potential customers. This was primarily due to the trade exaggerating the technical capability for export models. Nonetheless, these orders brought in jobs to keep plants warm, and undoubtedly assisted in bringing down costs for the government, primarily through indirect costs. The government for its own part was usually more than willing to allow such

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<sup>114</sup> ADM 1/7834. D.N.O. Director of Naval Ordnance In-letters 1905 May-June.

<sup>115</sup> Vickers Ordnance [Box prefixes VAO and VOR]

business, as it was mutually beneficial, although it did have a final say if the capability could cause potential political or military difficulty later.

Exports were not limited to suppliers outside the realm. Although India provided almost all of its finished artillery at Cossipore, other markets did rely on British manufacturers to supply artillery for their warships and regiments. Canada was the largest of these markets, with Australia and New Zealand as well as South Africa purchasing artillery from British manufacturers. There is some evidence that Canada imported raw forgings as early as 1902 from manufacturer Hughes-Johnson, and they were inspected at Woolwich, although it is unknown what these forgings were particularly for.<sup>116</sup> Canada placed an order in FY 1910 for 44 18-prs and 24 13-prs, as well as 36 18-prs in FY 1913. These orders were for the outfitting of the Canadian Militia, and were directed, non-competitive orders to Vickers. Begrudgingly, the Army Contracts Office acted as the intermediary and inspection point on behalf of the Canadian Government.<sup>117</sup> This directed contract was likely a direct response to Vickers having an industrial presence in Canada. Vickers operated a shipyard near Montreal in the closing years of the Edwardian period, which could have influenced the central government. Any indication of this

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<sup>116</sup> WO 254/1 General Note Book

<sup>117</sup> WO 395/3 Annual Reports 1909-1914.

though was never articulated by the Chief Superintendent of Ordnance Factories or by the President of the Ordnance Board.

In addition, between 1911 and 1914 several other Commonwealth countries modernized their field artillery, and all guns were built by the Royal Gun Factory. These orders do not appear on the annual audits of the Ordnance Factories because they were paid for through Commonwealth funding, and not Vote 9 funding. Australia acquired 21 guns in 1912-1913 and a further 39 in 1913-1914. New Zealand procured 16 18-prs in 1912-1913 and eight in 1913-1914. In addition, 4.5-inch howitzers were being procured by the Commonwealth as well. Both India and New Zealand acquired eight each in 1912-1913, and India procured an additional 13 in 1913-1914. South Africa became the only user of the 13-pr outside Great Britain and Canada by procuring 12 such guns in 1913-1914.<sup>118</sup>

### Technology

The 1890s saw a revolution in gun making. For the first time, high quality steel could be produced at reasonable costs. Adding to this, the introduction of chemically based propellants, known as smokeless powder,

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<sup>118</sup> MUN 5/179/1200.1/2. Tables of output of guns and carriages from March 1911 to March 1914 prepared from Royal Ordnance Factory balance sheets.

eased or eliminated constraints that had plagued designers for decades.

The evolution of propellants had three major effects on gun design. First, smokeless powder burned at a much slower rate than black powder. This allowed more energy to be transferred to the projectile, increasing the force imparted, and increasing the range and effectiveness of the system.

Secondly, it created a much greater pressure inside the barrel, necessitating a shift to all-steel guns. Before this time, guns were made up of everything from gunmetal, (a specialized form of brass) to wrought iron and cast steel.

The new pressures necessitated all-steel guns utilizing new metallurgical processes and materials that were first brought to light in the naval armour race that kicked off in the late 1880s and continued through the first decade of the 20<sup>th</sup> century. Thirdly, the new powder was not as corrosive as previous propellants. Earlier attempts to make efficient breech loaders, especially for small arms, were stymied by the frequent jamming caused by the fouling. It would not be possible to make efficient machine guns until this new propellant was invented.

Undoubtedly, the introduction of smokeless, nitrocellulose and nitro-glycerine based powder had the greatest effect on designs. It enabled steel and manufacturing advances to be fully utilized whilst also encouraging the research and design assets to be focused on harnessing its new properties. This was probably most realized by naval gun designers, as

their works were the largest in every regard. The initial problems with the new powder were based on its inherent instability as it was a chemical compound, and as such was prone to degradation. Each country tackled the new propellant problem differently, and therefore their gun designs were products of their powder, and not vice versa. It could be argued that the gun designs each industrialized nation produced were the mirror of the chemical and scientific community as much as the military community.

In the nationalism-charged climate of the 1890s and 1900s, the ability to be self-reliant in war items certainly played into the powder issue, and by the end of the century, each country had settled on their basic propellant designs. Two schools of thought emerged, with powder being made to take extrusion or crystalline shapes. Britain would choose Cordite, a powder that was extruded into long strings that resembled pasta. This design allowed propellant packages to be tuned to the gun through changing the thickness and the length of the extrusion, thus changing the surface area. The weight and therefore theoretical maximum energy released was tested. This was to learn how to control the Cordite's burn rate, a driving factor that affected not only maximum pressures created in the bore, but also the theoretical maximum velocities of the projectiles as they left the barrel. If propellant designers could control this the most efficiently, the gun designs could be theoretically lighter as the pressure to

velocity factors could allow lower pressures, and therefore less steel was required in the manufacture, a key element in field as well as battleship guns.

One of the most difficult elements that enabled design was the study of internal ballistics. Internal ballistics focused on what happened to the gun and the projectile when a force was exerted. This force was in the form of the propellant releasing its energy through burning. If the burn rate could be tuned, the gun and projectile could be tuned for key performance parameters, including muzzle velocity, barrel wear, projectile weight, impact energy at the target, and accuracy. Cordite had to be very tightly controlled to confirm that its properties were in line with the standard specification. In 1906 the Principal Experimental Officer, Woolwich, Major J.H. Mansell, noted that between lots there could be variances of up to 15 feet per second in muzzle velocity, which could, on larger guns make a target miss by up to 300 feet simply due to the particularities of the powder.<sup>119</sup>

When British staffs mulled over these ideas at the beginning of the century, the scientific studies were all but conclusive. It was said in the international community that cordite was inferior to nitrocellulose powders

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<sup>119</sup> WO 33/2960 Report of the Committee appointed to consider methods of inspection and delivery of naval ordnance and naval ordnance stores.35



created on the continent and America, although British tests were showing the opposite, with better results than propellants that were being imported, and cordite could be acquired at a third of the price.<sup>120</sup> The ideal situation of course would be to find the propellant that offered the highest velocity with the lowest pressure.

In regard to higher velocity, and therefore more kinetic energy imparted to the projectile, thus giving longer range and more damage to the target, this could be achieved by two primary ways: first, increasing the charge of the propellant, thus giving more initial energy to the projectile, or increasing the length of the barrel, which would give more time for the powder to impart the energy of the propellant to the projectile, thus increasing range as an exponential element of internal ballistics calculation on the system as a whole.

Experts in the government spent great amounts of resources and time in exploring what was believed to be in the best interests of the services and the Treasury. The Master General of the Ordnance, the Director of Naval Ordnance, the Chief Superintendent of Ordnance Factories, the Superintendent of the Royal Gun Factory, and the Superintendent of the Royal Gunpowder Factory made up the cadre of

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<sup>120</sup> ADM 1/7756 Remarks by Rear Admiral Parr, Vice President O.C. and Associate Member of Explosives Committee on NITROCELLULOSE PROPELLANTS AND EROSION. 1903.

experienced individuals who had the job of delivering the best and most scientifically advanced equipment to British sailors and soldiers. This testing demonstrated a scientific prowess of high ranking officers as well as civil servants employed in high ranking permanent positions. The knowledge enabled strategic decisions to be made by those in uniform and for those in uniform, making informed decisions on equipment to the contracted trade, not vice versa as has been associated with technical arms in Britain since the 1950s.

### Designing Cordite Guns

In the 1880s European naval architects developed new warships with armour that could counter explosive shells fired from new breech loading guns. The race was dominated by firms that could use new steel alloys and new techniques for rolling the massive armour plates required by shipbuilders. The technology in new materials was directly put into gun production. In an unusual example of the time, armour was left exclusively to the Trade, leaving the Royal Factories to their more traditional role of gunnery work. This probably had to do with the changing role post 1888 of the role of the arsenals as an insurance policy as armour would not represent a great need at the outbreak of war. It is also noteworthy to mention that British industrial policies with armour manufacturers

mirrored the policies of the American Navy. It is not a far stretch though to state that the international armour market was quickly becoming a commodity of very high quality alloy steel, much more so than the trends in gun making over the same period. It was not uncommon for buyers to go overseas for armour as it was effectively a commodity, although it was very uncommon to pursue foreign guns, both in the field and afloat.

Britain had a history dating back over 30 years in regards to manufacturing techniques of artillery for all services in a way dissimilar from all other powers. By the late 1850s and early 1860s wrought iron and steel replaced bronze in artillery, although gun design quickly outstripped the technology available to produce large guns in one piece. Steel artillery design and production worldwide fell into two separate designs: built up, and wire wound. Built up guns were based on the original principles discovered by Armstrong in the first steel guns in the 1860s. It consisted of a group of stacking sleeves of steel, each sleeve shorter than the last, but also overlapping the smaller, longer sleeves below until a desired thickness was reached to manage gas pressures of the propellant.

Armstrongs pioneered the wire wound guns, which conversely, were built around an inner 'A' tube that was hardened and rifled to the precision of the projectile, and wire was essentially wound around the tube until the desired thickness was achieved. Once this occurred, an outer tube would

be placed to protect the wires and give lateral rigidity to the entire structure. In the case of the 12-inch guns, there were 117 miles of wire wound around the 'A' tube to complete just one gun<sup>121</sup>. Both gun designs relied on compression of the subsequent outer jackets to create a force that worked better during the propellant's burn.

Gun design had to incorporate an understanding of all the forces involved in both production and firing. The artillery barrel was the most complex and technically demanding piece of equipment both on the high seas and the battlefield. A field gun had to be light enough to be pulled by six horses, resilient enough to fire 15 rounds a minute, yet strong enough to not explode at the pressures in excess of 50,000 PSI. As well it had to be durable enough to take 10,000 rounds before being sent back for relining. Naval guns had to withstand even increased pressures, and weight was not just a land based issue. The guns were some of the highest pieces in the centre of gravity of a ship. As well more weight in the guns meant more weight in strengthening the gun mountings. The balance of guns, especially as barrels became longer, became a great source of innovation for designers in both Woolwich and the Trade. The length of a barrel was a direct calculation as to the size of turrets on ships. On battleships, the size of the turret became the key design feature, as a wider turret meant the

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<sup>121</sup> *Popular Science Monthly*, July 1917. 44.

ship also had to be wider, and wider ships meant greater resistance in the water. Longer and heavier guns therefore had a great effect on the design of ships. Britain generally designed ships without restrictions as to width, although this also meant the British battleships were not designed to traverse the Panama Canal when it opened in the fall of 1914. This was a direct result of the size of guns on British battleships. Naval guns also had to survive a long career exposed to the elements of the sea. The slowest projectiles in the post-Dreadnought era on main armaments easily exceeded twice the speed of sound by the time they left the barrel. These barrels therefore had to take acceleration forces of a projectile accelerating at a 0-60 miles per hour rate in about one foot.

Durability and rebuildability were foremost on the minds of the bureaucrats on the Ordnance Board. It was inevitable that if a gun served long enough, it would be required to be sent back to Britain to be rebuilt. Rebuilding artillery was a task that uniquely suited Woolwich, as the Government believed that each rebuild was different and therefore no accurate price estimate as to the work to be performed could be calculated. Therefore all work with very few exceptions was sent to the Royal Gun Factory. As the inspectors were also assigned to Woolwich, this had a double-edged benefit for the services. Not only from the aforementioned cost perspective, the inspectors could undertake experiments with the worn

tubes to ascertain what had caused the wear and tear, to better incorporate into new designs. This information could be reported up to the Ordnance Board/Committee as well as down into the user community. Because inspection work was generally done by officers at the Colonel/Captain level and their Major-Lt. Colonel staffs, they had by the end of the Edwardian period perfected this learning cycle, gaining valuable experience and technical research, while also costing taxpayers less. It appears from the Murray Report that in the event of conflict, after Trade mobilization occurred, Woolwich would continue to perform this valuable service of relining and rebuilding artillery.

### **Nickel Steel**

The introduction of high grade composite steel at the end of the century brought new challenges as well as opportunities. The primary steel took the form of nickel steel, although chromium, vanadium, and other trace materials were experimented with to harden steel. As was discovered though in a 1902 Ordnance Factory test, some such as vanadium were simply too hard to machine, thus making them unsuitable to use. The

government experimented with adding carbon, manganese, silicon, vanadium, nickel, copper, and chromium.<sup>122</sup>

The basis of the final specification was set forth in 1904 as:

Nickel: 6%

Carbon: .3

Silicon: .2%

Manganese: .9%

Sulphur: .05%

Phosphorus: .04%

Copper: .05%<sup>123</sup>

As metallurgy expanded and matured in this period government and civilian research would continue to push knowledge of materials even further. Much of this change in gun steel was pushed down to the secondary suppliers who made raw forgings for the primary suppliers as well as Woolwich. This transition was not always smooth. For instance, in the 1909 FY alone, 104 tons of nickel steel was rejected for having segregation out of 1182 tons received.<sup>124</sup> The steel due to its increased hardness and increased density required new procedures, and in some cases, new tooling, as old tools designed for carbon steel could simply not work the harder components. Entire processes had to be rethought of, including a curious case at Woolwich where specific gravity was incorporated into the initial stages of production to ensure the best

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<sup>122</sup> SUPP 5/926. Metallurgical Researches: Use of sheared samples for preparation of test specimens: report Report R.G.F #11.

<sup>123</sup> SUPP 6/65. SUPP 6/65 Annual reports of the president. 1905. 14.

<sup>124</sup> SUPP 5/927 Metallurgical Researches: Case hardening experiments with Cyanide baths and other Carburising materials: Report R.G.F. Report RGF #12.

product.<sup>125</sup> The process of accepting the new alloy steels will be discussed in the following chapters.

## Conclusion

By 1914 British capacity was well established. Two senior commercial companies dominated the private trade, with Vickers and Armstrongs both being able to produce all sizes of ordnance of equal quality in their factories in Sheffield and Elswick respectively. Each of the companies also had smaller concerns, with Armstrongs producing quality products at their Openshaw plant while Vickers had a strong proxy in Beardmore making naval guns for the newest battleships. In addition, Coventry Ordnance Works on their own could make all land based artillery as well as having the benefit of being able to utilize the skill of their three parent companies. Finally, the Royal Gun Factory at Woolwich was able to not only produce, but also repair everything in service. British capacity for artillery production had never been higher in the history of Britain, and British steelmakers were at the front edge of research, being able to produce alloys to continuously improve products already in service as well as guns yet to be designed.

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<sup>125</sup> SUPP 5/927 Report RGF #15.



As July 1914 rolled around, nothing seemed out of the ordinary for the technical staffs. The second quarter of the 1915 Fiscal Year had just started. The second and third quarters were traditionally when most of the capital investment contracts had been placed over the last decade, and staff work and quote preparation would have dominated most staff members' minds. Little prepared them for the overnight change in tempo that was to roll over them like a tsunami. British civil staffs were efficient, although they were very limited in numbers. Clerks took years to learn contractual and fiscal law. Again, officers in both blue and khaki had developed years of experience in all aspects of ordnance, from design to inspection and everything in-between. Their experiences were the product of well over a decade of professional learning and perseverance. Members of the Trade as well represented years of goodwill and working experience with the Government. Their capacities were well known and their capabilities well tried. The final product was a very well trained and tested system of peacetime procurement and management. It was qualitatively strong and quantitatively small. The events of August 1914 would test if these staffs could be transformed into a quantitatively large administration whilst also maintaining a high qualitative standard.

## **CHAPTER FOUR: THE CASE STUDY OF THE FIELD**

### **ARTILLERY RECAPITALIZATION, 1900-1907**

#### **Introduction**

In previous chapters, this thesis has looked at the demand for and supply of armaments in Britain between 1900 and 1914. This chapter will look at how pre-war procurement was actually conducted. The case study for this chapter will be the process and procurement of the largest single contract for British artillery before 1914: the Royal Horse and Field Artillery recapitalizations.

The 18-pr in particular was one of the most important artillery pieces of Britain in the twentieth century. It was one of the most widely produced guns in British history, and served throughout the British Empire from 1907 through to the Second World War, when it was supplanted by the 25-pr, which itself was an evolution of the older 18-pr.

Military historians have often seen the process (or lack thereof) of design and procurement as something of no importance for later operational uses of guns. Almost exclusively, military historians, as well as the units they write about, are not interested in where the guns came from or how their particular design features were put into the final production model. To misunderstand the process of how weapons come into being

ignores the fundamental rationale for how they will be used by the service and how doctrine and therefore the force structures as a whole are crafted.

This chapter will demonstrate how exactly the War Office acquired the 18-pr by analysing issues relating to the state of technology, the experiences and prejudices of the selection committee, the state of British industry and considerations in produceability of field guns in Britain, developmental and operational testing and how lessons learned from testing were inserted back into the program. Finally, we will discuss the industrial issues of production through the way in which the Director of Army Contracts procured the guns. This chapter will not discuss how the service utilized the pieces after they were accepted for service.

### **British Army Recapitalization: Background**

By the end of the nineteenth century, British artillery was quickly becoming obsolete. The Field artillery had been made obsolescent overnight when the French army revealed the *Mle 1897* 75mm gun, named after its year of introduction, 1897 and affectionately known as the *Soixante Quinze*. Britain had to recapitalize although it was soon embroiled in a war in South Africa from 1899 through 1902 that drained the budgets of the service. It would have to wait until the end of hostilities to evaluate the need along with future desires.

The table below represents the rapidly changing and relative nature of field artillery. The graph lists the old British 15-pr field gun, the new 18-pr and the contemporary 1897 French 75mm and the 1896 German 76mm. The particular contemporary example comes from the Hansard of the House of Commons in response to a question asked by a Minister of Parliament.<sup>126</sup>

**Table I**

**A comparison of contemporary artillery prepared for Parliament**

	15 Pr. Converted	British 18 Pr.	French 75	German 76
(1) Effective Range (Yards)	5900	6200	6010	5500
(2) Muzzle Velocity (Feet Seconds)	1581	1590	1736	1525
(3) Extent of Recoil on Carriage	3.4 ft	3.4 ft	3.57 ft	3.66 ft
(4) Extent of Recoil on Ground	Nil.	Nil.	Nil.	Nil.
(5) Number of Bullets in Shrapnel	230	364	300	300
(6) Rate of Aimed Fire per Minute:	Trials Not Yet Complete	20	20	20

From the chart above, the relative merits of the new 18-prs that replaced the old 15-pr is substantial and justified the immense cost of

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<sup>126</sup> Hansard *HC Deb 5 March 1907 Vol 170* Statement by Mr Arthur Lee. 627.

outfitting the Royal Artillery and Royal Horse Artillery. Increasing the projectile breadth by less than 1 inch gave an increase in shrapnel by 58 per cent, as well as an increase in range for what was effectively the same weight of a weapon for the purposes of mobility. What was also demonstrated was the weight of the projectile in comparison to the two European rivals, the famous French 75mm and the German 76mm. Although the 15-pr was obsolescent for front line service, it was believed to be more than adequate as a field piece for the newly formed Territorial Force for whom it was updated and converted for.

### The 13 and 18-pr Case Study

In May 1901 a committee of artillerymen and engineers met to discuss the future of field artillery in Britain. This committee would eventually decide to recommend into British service the 13-pr gun for the horse artillery and the 18-pr for field artillery. These guns would become the backbone of not only the largest professional army in Europe by 1914, but would also stand as the primary guns of a volunteer British Expeditionary Force that made their stand from the Fields of Flanders to their twilight in the sands of Operation Torch in 1942, four decades after their design.

The committee itself was a special committee created from the Ordnance Committee, the overarching lead for all warlike stores for all services afield and afloat. The special committee was chaired by Major-General Sir G.H. Marshall, KCB, RA and four regular members: Lieutenant-Colonel WE Blewitt, CMG, RA, Lieutenant-Colonel B. Burton, CB, RHA, Lieutenant-Colonel WFL Lindsay, DSO, RFA and Major S. Belfield, RHA and two consulting members: Major-General TB Tyler, RA, representing India, and Bt. Lieutenant-Colonel A Hamilton-Gordon, RFA, consulting howitzers, and Lieutenant-Colonel ND Findlay, RA as secretary.

The committee recognized at the outset that much was to be learned from South Africa, although many of the conditions were one-off and should only be followed with analytical care. They ‘look upon the Boer War as having afforded much experience and many valuable lessons, but some of the conditions are exceptional and unlikely to be met with again.’<sup>127</sup> The committee’s works were designed with the mindset to meet as many ordinary needs, and to not meet ‘extraordinary’ needs. They also believed that a European war would require ‘well-served guns firing accurate time shrapnel’, and not high explosive or ‘ordinary’ rounds.<sup>128</sup> Another lesson learned were that ‘the utter inefficiency as man-killers of common shell

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<sup>127</sup> SUPP 6/544. Extracts from proceedings Royal Artillery Committee. 3.

<sup>128</sup> Ibid. 3.

(even at 100 pounds in weight) fired from guns even against defined and located targets, and the efficacy of good time shrapnel under similar circumstances'<sup>129</sup> This came from a 'lesson learned' that High Explosive rounds were not accurate enough to use for anti-battery purposes, and difficulty was had with consistency of high velocity shells keeping intact, including the delicate driving bands. Because of these observations, they believed that shrapnel was the only means of delivering killing power, with the available technology, and in the quantity needed.<sup>130</sup> The committee defined effectiveness as 'its capability of pouring the greatest number of effective bullets on a given area in the shortest possible time.'<sup>131</sup> This again favoured shrapnel as imperfect and inconsistent fuzing forced British designers away from impact and air burst shells. They also came to the conclusion that the Royal Horse Artillery and Royal Field Artillery pieces required different methods of evaluation, with the mobility of a horse piece being the predominant factor and gun-power being the predominant for the Royal Field Artillery. The committee also believed that a six-horse team was the most economical use of resources, and therefore drove weight to 28-cwt for Horse Artillery, and 38-cwt for field artillery, exclusive of men or men's kits. Thus, the goal was 'of Horse Artillery

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<sup>129</sup> Ibid.

<sup>130</sup> Ibid. 6.

<sup>131</sup> Ibid. 3.

obtaining a thoroughly mobile gun of sufficient power, and Field Artillery a thoroughly powerful gun of sufficient mobility.’<sup>132</sup>

The committee considered that ‘a range of at least 6,000 yards with accurate and effective time shrapnel’ was required from a carriage that could reach 16 degrees elevation, and a remaining shrapnel velocity of 600 feet per second. These specifications represented not only the contemporary view of the war just fought, but the war to be fought, at some unspecified date, and with some unspecified enemy, on some unspecified continent.

The committee took a hands-off approach as the best way to gain quality initial designs. This was in large part due to a competent industrial base with experience for both domestic and international customers. Items such as calibre and length were left to manufacturers. Even seemingly important items such as the ability of the gun to be quickfiring were not requirements at the early stages of the competition.<sup>133</sup> Quickfiring, or QF as it is commonly known, meant that the propellant and projectile were in a single case, and therefore could be loaded in a single movement, often with the powder in a brass casing. The alternative was to load propellant and projectile separately. The quickfiring issue was looked at through the technical lens of positives and negatives with regard to the weight of the

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<sup>132</sup> Ibid.

<sup>133</sup> Ibid. 4.



brass casing. This casing weighed between one and three pounds and a full load of quickfiring munitions might weigh as much as one cwt or more.<sup>134</sup>

Amazingly, by 1902 the committee appears to have not wholeheartedly required a hydro-pneumatic recoil system, although the specifications laid forth by the committee really left no choice but to accept such a system, given the state of technology at the time, and the relative power of artillery on the continent, especially France and Germany, and to a lesser extent, Russia.

The committee considered the use of the 5' howitzer in South Africa during the course of specification design. This appears to be due to the 5' not being used at all in lines with its designed parameters of being siege artillery, and instead acting as heavy field artillery. Because of the inherent weaknesses of the common or high explosive shell, the gun was not as effective as it could be. This issue was almost wholly in the design of fuzing, which appears to have been in this particular case a contact fuze only. The committee did point out that the round was probably too large for the range that it could use, and suggested a smaller projectile and a longer range. This would of course be used half a decade later when Coventry released the 4.5' howitzer. The committee seemed to suggest that a new howitzer was needed, but did not seem interested in procuring it for

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<sup>134</sup> Ibid.

the purposes at hand. Understanding the relationship between the field gun and the field howitzer is integral to understanding how the field gun evolved, and what requirements were associated for each to achieve the capacity of mission.

The committee suggested reworking the ammunition columns with a two tiered system, totalling 450 rounds per gun in the field.<sup>135</sup> This would have been a massive increase, as required by quickfiring artillery, but at the same time, would have only been enough for about 25 minutes of firing at full rate. This amount of munitions provision would have also been a great expense, as rounds in the field degrade much faster than in arsenal storage.

### **Brackenbury's Response**

The Director General of the Ordnance, the predecessor position to the Master General of Ordnance, Major General H. Brackenbury, responded in a memorandum dated 10 May 1901, challenging several points of the committee's requirements paper. He specifically challenged the primary qualities of mobility in the horse artillery, arguing that the firepower and capacity would not be available with the weight specified, based on the current fielded equipment. He also argued that accuracy and speed were not available with the recoil mechanisms suggested by the

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<sup>135</sup> Ibid. 13.

committee. The French and Germans (in the French 75 and Ehrhardt systems respectively) had mature recuperator designs, although the Director General of the Ordnance rightly pointed out that the Committee wanted some sort of magical device that was to contemporary knowledge not even invented, let alone engineered, tested, and perfected. The Director General of the Ordnance, though, was most pressing over how far the committee was willing to lose ammunition capacity for the sake of saving weight as a representation of increased capacity in the key parameters.<sup>136</sup>

### **Committee Response and Industrial Actions**

The Committee responded ten days later on 20 May, 1901 that they truly believed that 28 cwt was achievable because of the inefficiencies of the old 12 and 15-pr guns. With this in mind though, it was decided to submit a specification package to industry with the 28 cwt and 40 rounds specification intact at that early stage. The committee decided that a shell under 18 pounds would be unacceptable for field artillery. This was driven by the current technology and understanding of the shrapnel round

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<sup>136</sup> Ibid. 15-16.

determining the size, without consideration of high explosive shell rounds.<sup>137</sup>

In an initial conference Vickers was represented by Mr Trevor Dawson, a former Royal Navy lieutenant who had risen to prominence while working at the Ordnance Factories at Woolwich. Vickers' initial impressions of a gun that could meet the velocity specifications of the army, were that either weight must increase or the quality of steel must increase to make the 28 cwt goal. It is unknown what internal ballistics Dawson was mentioning, but in all likelihood, this was the goal of 6000 yards range with a shell weight greater than current. Vickers proposed to have a hydraulic based recoil mechanism 'the system of the French.' This, along with a 40-inch recoil, was meant to be a long recoil system. It appears on the whole that the Vickers design was a product of close inspection of the French 75, and attempted to improve on that style of gun.<sup>138</sup> Dawson claimed that an incorporation of springs into the recoil saved 1 cwt over the entire unit, although admittedly increasing complexity.

Dawson commented that 'the more weight you have the better means you have of overcoming the energy without movement of the carriage.' Dawson repeatedly suggested that one of the keys to the success of achieving the key performance parameters of the gun weight would rely

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<sup>137</sup> Ibid. 17.

<sup>138</sup> Ibid. 22.

on using better steel, although the committee did not seem interested in such a proposal at the early stages of building.<sup>139</sup>

Dawson wholeheartedly approved the use of fixed munitions on multiple grounds, although mainly the belief that the French utilize it, which was the test of quality.<sup>140</sup> As a parting question, Dawson was questioned on Krupp fuzes, and very insightfully, he commented that the fuze and the gun must be a paired object. If two guns are the same except for their rifling, the fuzes will not work right. Barrels and munitions would have to work in concert to provide effective firepower.<sup>141</sup>

Next on the interview process was Mr George Hadcock of Armstrongs. Hadcock's answers to the committee were more grounded in reality than Dawson's, answers based on technical expertise rather than trying to sell a product. Hadcock believed that case ammunition was the only reasonable answer for quick-firing guns, yet he admitted the weight added nothing ballistically. He was also questioned about the effects of heat, a question that did not come up with Dawson.<sup>142</sup> One effect of shrapnel was that the gun could fire at a lower initial velocity, (shorter barrel) because the booster in the shell accelerated the rounds by up to 190

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<sup>139</sup> Ibid. 23.

<sup>140</sup> Ibid. 24.

<sup>141</sup> Ibid. 25.

<sup>142</sup> Ibid.

feet per second, a very large amount. As well, a .5-inch ball would penetrate 2 inches of oak at 'long range'<sup>143</sup>

Finally, Col E Bainbridge, CB, the Chief Superintendent of the Ordnance Factories (CSOF) was called to speak. He quickly mentioned a measure of effectiveness of the gun through the amount of rounds carried, which he estimated at 30 and 34 for a horse and field equivalent respectively.<sup>144</sup> He disputed trade claims about the number of on-target shots that could be achieved in one minute. He believed that seven rounds was the maximum achievable, but cited that HMS *Excellent*, the Royal Navy's gunnery school, fired out of the 12-pound, 12 cwt gun five times in 23.5 seconds, which was then the British record. Bainbridge was adamantly against case ammunition for two-fold reasons: first, he believed them to be innately less safe than separate munitions, and secondly based upon weight, that for every nine rounds, he could have one more if they were not cased. He recanted a few questions later and submitted an idea for Royal Horse Artillery guns firing case whilst the Royal Field Artillery guns fired separate charges, exclusively due to weight.<sup>145</sup> The Chief Superintendent of the Ordnance Factories based his assumptions of pneumatic springs on a workable recoil mechanism based upon the 9.2-inch howitzer. (This would

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<sup>143</sup> Ibid. 26.

<sup>144</sup> Ibid.

<sup>145</sup> Ibid. 27.

not be completely tested until July 1914 at Shrewsbury with ‘Mother.’)<sup>146</sup>

With these expert testimonies, the government released their specifications.

### **Key Performance Parameters**

On 8 July 1901 the committee released their key performance parameters that had to be met for the Royal Horse Artillery. The gun was to be quickfiring, carry 40 rounds, and weigh no more than 28 cwt behind the team. Ballistically, it had to deliver accurate shrapnel fire to 6,000 yards at 16 degrees and have a remaining velocity of 600 feet per second at that range from a 12.5 pound shell.<sup>147</sup>

The calibre of the barrel was not stipulated, except that the committee did request it should be as short as possible. This would have also been in the interests of the manufacturers as it would have saved weight, so it is not a surprise. Open sights were a requirement, with telescopic sights being optional. Pneumatic recoil mechanisms were banned in the initial specification.<sup>148</sup>

On the same day, 8 July 1901, the War Office released the conditions for the field gun. The gun should be quickfiring, with shield,

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<sup>146</sup> Ibid. 28.

<sup>147</sup> Ibid. 31.

<sup>148</sup> Ibid. 32.

carriage and limber, and when packed with no less than 15 rounds, should not exceed 38 cwt. Ballistically, the gun should accurately fire shrapnel to 6,000 yards at 16 degrees with 600 feet per second delivery velocity. The shell had to weigh at least 18 pounds.<sup>149</sup>

The competition was run with the following requirements of evaluation in descending order: shell power, ballistics, and weight behind team were requirements, while rapidity of aimed fire, provision of shield, and number of rounds carried were trade-off factors. Shell power was measured by highest ratio of the total weight of bullets to total weight of projectile.<sup>150</sup> All other particulars, including recoil mechanism, brakes, wheel size, etc were identical to the Royal Horse Artillery piece.

### **Delivered Test Guns**

The Ordnance Factories, Armstrongs, and Vickers all delivered guns for both competitions. All guns failed to pass the tests. Some of these failures were minor, although, the failures were still bad enough for the committee to tell all manufacturers to redesign.

For the horse artillery, the Ordnance Factories submitted guns that were too heavy, worse, carriages were flimsy, and they were inaccurate.

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<sup>149</sup> Ibid. 34.

<sup>150</sup> Ibid.



Armstrong's submissions were not accurate, not powerful enough, and too heavy. Vickers guns were too heavy, too lively, and had no optics.

For the field artillery, the Ordnance Factories gun was inaccurate, and it was too heavy, the Armstrong's gun was too heavy, and Vickers submitted a gun that was too heavy, did not have optics, and had an inadequate shield.

The committee and the competition were conducted in an atmosphere of collegiate competition. After the tests at the proving ranges and road tests, the makers were also able to inspect not only their own submissions, but were able to inspect in detail those of their competitors when the systems were taken back to Woolwich. Although this certainly would have given the most eyes on the problems at hand, it would also have exposed each design and their successes and failures.

### **Recommendation**

For the Horse Artillery competition, the committee decided that in their opinion the best solution would be to make a Frankenstein gun composed of the best bits of each design. The gun was to be based on Vickers, but with the Armstrong's sliding breech block design. They suggested that the gun could add up to one cwt, but still be within the regulation 28 cwt pulling weight. The committee believed that stability

could be created by slowing down the muzzle velocity of the gun, and thus the total energy in firing, and believed this was possible while still getting 600 feet per second at 6000 yards. Sighting was to come off of the Ordnance Factories gun. Much of the carriage was to be from Armstrong's, but it must improve in 16 areas.<sup>151</sup>

For the Field Artillery competition the recommendation of the committee was that the gun and breech were to be from the Armstrong's gun, but with an improved mechanism. The buffers and running out gear were to be from Vickers, and the sighting and elevating were to be from the Royal Arsenal, although that of the version for the Royal Horse Artillery piece.

After the gun testing, the panel switched requirements from that of the biggest shrapnel delivery device possible to a more refined one that was more stable at firing, being willing to give up significant weight of shell to do this.<sup>152</sup>

### **Post-test interviews**

On Thursday, 23 October 1902 Sir Andrew Noble of Armstrong's was interviewed by the committee.<sup>153</sup> Noble suggested adding weight to the

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<sup>151</sup> Ibid. 46–47.

<sup>152</sup> Ibid. 60

<sup>153</sup> Ibid. 57.

Royal Horse Artillery gun would control recoil, as well as adding four calibres to the length to increase end velocity of the projectiles.<sup>154</sup> As the gun itself was settled on as the Armstrong's for the 18-pr and the Vickers for the 13-pr, each would be more focused on perfecting and tuning.

Apparently the British shrapnel shells were considered comparatively stout in comparison to others, especially the Italians. Noble mentioned in the conference that he believed the wall should be thinned as the easiest way of increasing performance of the system.<sup>155</sup>

Dawson was interviewed representing Vickers on 23 October 1902. He thought there was no need to lighten the shell for the Royal Horse Artillery project, judging that increasing gun weight and lowering muzzle velocity would take care of the issues.<sup>156</sup>

(President) 'Do you wish to make any general remarks upon any points which have not been brought forward by the members of the Committee? (Dawson) I would like to say that in connexion with this question we hope when the time comes for placing orders, it will be borne in mind that we have for many months been spending large sums of money and experimenting at great expense and that we are prepared to give the War Office the use of any design or invention we may make in connexion

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<sup>154</sup> Ibid. 57, 59.

<sup>155</sup> Ibid. 59.

<sup>156</sup> Ibid. 65.

with these experiments. This would be done of course, after some arrangement has been made by which we keep the secrecy of the design between Woolwich Arsenal, Messrs. Armstrong, and ourselves. Bearing these points in mind, we ask that we should be given a proper and fair share of the orders'<sup>157</sup>

Dawson's comment on the field artillery was that of again selling his products. He stated he saw no reason why Armstrong's design should be selected over his own and that he thought that the Vickers projectile was more effective as it had more bullets. This did not receive a response from the committee.<sup>158</sup> All of Vickers suggestions were made in such a way as to appear to claim patents whenever possible. For instance, both the Vickers screw breech and the Grubb sight were recommended strongly by Dawson. Both of these were very tightly held patents by Vickers, and stood to make large sums of royalties from their use, no matter the manufacturer.<sup>159</sup> In general, Noble spoke as an engineer, Dawson spoke as a salesman, and this certainly would have had effects on how the committee viewed each, one as a technical partner, and the latter as a business partner.

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<sup>157</sup> Ibid. 66.

<sup>158</sup> Ibid.

<sup>159</sup> The Grubb sight was patented under Patent Specification 20,813, accepted 26, Oct 1901. The Patent was partially in Dawson's name.

## Ordnance Factories

Col Bainbridge was interviewed as the CSOF. Also interviewed were Maj Fisher, Royal Carriage Factory, and Lieutenant-Colonel HCL Holden of the Royal Gun Factory. As the designs submitted by the Ordnance Factories were not ultimately accepted, the body could be used as an unsung integrator and challenger of the trade designs. Bainbridge pointed out that ‘the difficulty that comes in here is that Vickers’ have got a light gun on a heavy carriage, while the EOC (Elswick Ordnance Company, also known as Armstrongs) have a heavy gun and a light carriage. I have worked out some figures, and find that the mean pressure of the carriage due to the recoil is in the Vickers equipment 4,156 pounds, whereas with the heavy gun of the EOC it is 2,464 pounds.’ He did not believe that the light carriage could handle such a force caused by so light a gun.

Vickers could not supply a single forging for the field artillery project, and did not bother ‘VM Co (Vickers Maxim) threw up the sponge at once, than had never supplied any.’ The gun steel could only be reliably be produced by Armstrongs, and therefore the Royal Gun Factory had to resort to ordinary steel.<sup>160</sup>

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<sup>160</sup> SUPP 6/65. Annual reports of the president. 1905. 201.

The Ordnance Factories submitted a completely new design that incorporated the Vickers gun, the Armstrongs breech, and a new recoil mechanism which was a long recoil with much stiffer springs. OF were afraid this design was the best but would weigh too much. In the end, Bainbridge was exasperated: 'I think after talking it over with the Committee, and when you make up your mind as to your recommendations, we shall be better able to do it.'<sup>161</sup>

Major Fisher complained that the Vickers design had too many pieces from one casting and that the overall design was not survivable. Fisher stated, 'Because the tubes are very thin, and if a bullet strikes the cradle with any velocity it would probably put it out of action altogether.'<sup>162</sup> He also complains that it appears the Vickers design is too expensive in construction, especially to be this fragile.

On 17 April 1903 the committee released their third report.

After making recommendations, the committee ordered a design in October 1902 of each the Field and Horse pieces that represented the strengths of each design submitted. Orders of a battery of four of each design were ordered from Armstrongs and Vickers for a total of 16 guns. These guns would be tested, including on a road trip from London to

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<sup>161</sup> SUPP 6/544. Extracts from proceedings Royal Artillery Committee. 70.

<sup>162</sup> Ibid.

Aberdeen and eventually some would go through destructive testing for survivability under machine gun and shrapnel fire.

The final report was released on 4 August 1903. By this point Lieutenant-Colonel Findley had taken over the majority of the day to day activities of the committee. The results of gun shooting were overall satisfactory, and ranges of 7,000 yards were achieved.<sup>163</sup> The largest challenge before ordering came from Blewitt, who did not believe that the 18-pr design chosen had overachieved enough to justify it being put into service, preferring to equip both regiments with the 13-pr, albeit with a 14.5-pound shell for the Royal Field Artillery. The 14.5-pound shell was more accurate than that of the 13 and 18-pr guns, and was less efficient in shell capacity, but it would have made up the difference in conserved weight.<sup>164</sup> Yet again, in 1907 the request for a 14.5-pound shell for the 13-pr appeared, this time from camp commandant, Okehampton. He argued it shot better, it had a lot more lethality, and it was more effective by weight by about 3%.<sup>165</sup>

This was backed up by officers who conducted the operational testing, who thought that it would be better served to use it for the horse artillery, scale it up to a 15 pound shell, and carry the saved weight (8 cwt)

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<sup>163</sup> SUPP 6/544. Extracts from proceedings Royal Artillery Committee. Report 4, 4.

<sup>164</sup> SUPP 6/544. Extracts from proceedings Royal Artillery Committee. Final report, 4-5.

<sup>165</sup> SUPP 6/67. Annual reports of the president. 1907. 133.

in ammunition. Although it seemed a good idea on paper, the idea was overruled. It is unknown what difference this would have made not only in the howitzer competition, but also in 1914.

On the second day of testing, nine shots were accurately fired over a minute; by day five, it was 15 by one gun.<sup>166</sup> The highest rate of fire recorded for the Horse Artillery was 50 rounds per six-gun battery although it was not able to be sustained.<sup>167</sup>

In March 1905, the final contract was signed to produce all the artillery for the Royal Horse and Royal Field Artillery. Two-thirds of the order went to the trade, split evenly by fiscal amount between Vickers, Armstrongs, and Cammell, which was in the process of transitioning the ordnance work to Coventry Ordnance Works. The remaining third was issued at the Ordnance Factories. Contract #73/4/5103 had 480 18-prs from the trade, broken down into 192 from Vickers, 192 from Armstrong and 96 from Cammell. This was based upon an agreement with the Director of Artillery in 1904 that Vickers and Armstrongs would combined receive 8/15 of the orders, and Cammell would get 2/15 of the orders, which left the Royal Ordnance Factories with 5/15ths of the order. In particular, and most importantly for the sake of policy, the Ordnance

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<sup>166</sup> Ibid. 27.

<sup>167</sup> Ibid. 14.



Factories and Cammell would not pay any royalties.<sup>168</sup> In addition, the same contract ordered 90 13-prs from the trade, broken down into 36 from Vickers, 36 from Armstrong's and 18 from Cammell. The even cost for each contractor came from other parts of the order, mainly vehicles, which Cammell received a much larger share of to make up the difference from the gun orders. The overall contract was just at £1 million, which in all likelihood was the largest contract, and certainly the largest peacetime contract, ever placed for armaments. Little is actually known about the third placed at the Royal Arsenal, as the contract was not recoded in the annual audits of the Royal Factories.

The Ordnance Factories ordered all of their steel for the barrels of their share from the Trade. Steel was sent to Woolwich for the purpose of 13 and 18-pr guns with 45 tons from Cammell, which was rejected, 90 tons from Cammell which was accepted, 12 tons from Jessop which was also accepted, another 10 tons from Jessop which was accepted, and finally 10 tons from Beardmore which was rejected.<sup>169</sup> These were delivered in 18-in diameter ingots.

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<sup>168</sup> ADM 1/7897. DNO. Director of Naval Ordnance In-letters 1906 Feb.; WO Paper 73/4/4726.

<sup>169</sup> Ibid. 200.

### Bending guns

In 1905 the 18-prs were starting to bend due to ribs improperly designed opposite each other on the barrel. This caused the “A” tube to stretch after firing rounds. This occurred at 74 rounds after experiments with cordite.<sup>170</sup> Four guns from each manufacturer were to be chosen for each of the 13 and 18-prs, 30 rounds were to be fired, 2 minutes apart, and measured at 15 and 30 rounds in their warm state to check for deformation. The resulting design changes might be the basis for the Mark II 18-pr guns, although there is nothing in the archives to substantiate or refute this.

Multiple guns from multiple manufacturers showed some bending, but it seemed to be usual practice for the manufacturers to straighten barrels before proof. The Royal Gun Factory products were the only guns that seemed to be immune from bending. This was due to the way they were heat treated.<sup>171</sup> Eventually, Cammell suggested cutting slots in the guides to avoid warping the barrels. This was approved by all and Cammell.<sup>172</sup> Apparently, the ribs they were talking about were the guide rods that the barrel sat on. The cutting experiments did not alleviate the issue, and apparently made it worse.

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<sup>170</sup>SUPP 6/65. Annual reports of the president. 1905. 61.

<sup>171</sup>Ibid. 64.

<sup>172</sup>Ibid. 65.

The most interesting discovery in the archival material was how batteries were initially deployed. Batteries were truly spread across makers, and each battery of the three cited in the test results were distributed within all four manufacturers. Two of the three batteries had all four makers, and included in this were guns made by the Royal Gun Factory. This is also conclusive proof of the Factory making guns in the Mark I batch. This meant that the guns, including the manufacture of different steels were equivalent in performance for the purposes of battery cohesion.

The mixed battery reports also showed that droop was occurring with all manufacturers, so it was a design fault and not a manufacturing fault.<sup>173</sup> This went against the initial studies. 37 of 38 18-prs tested were drooped, and 12 of 12 13-prs tested were drooped.

Several guns were so warped that they had to be removed from service. Gun 114 was test fired in June 1905. 10 rounds were fired in 40 seconds, 13 rounds in 56 seconds, and 7 in 19 seconds.<sup>174</sup> This gun was eventually accepted for cordite testing purposes, but was too bent to be used for active service.<sup>175</sup> The 18-pr gun, number 255 confused much of the initial ability to fix the problem. It appears that almost every gun after the 1906 trials showed signs of bending. Some, such as gun No 264 were

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<sup>173</sup> SUPP 6/66. Annual reports of the president. 1906. 47.

<sup>174</sup> SUPP 6/65. Annual reports of the president. 1905. 62.

<sup>175</sup> SUPP 6/163. Annual report of the president. 1908. 13.

so bent at the rails that they could not be remounted on their carriage after measurement.<sup>176</sup>

The jams to this particular gun were not caused by bent rods as first thought, but by the recoil cylinder head seizing in the inner spring case.<sup>177</sup>

After a year's use, only one gun was beyond the limit in bending, but eight were reaching the limit. All other guns that showed signs of bending were bent back and had been satisfactory. At the end of the 1907 exercises, it was decided to take no further action on the Mk I 18-pr guns.<sup>178</sup> The redesign of the 18-pr and 13-pr were assigned RGF designs 11,090/35 and 11,100/41 respectively.<sup>179</sup> In the end, it appeared that if an 18-pr was to bend, it would happen at proof and in the first few rounds. After that initial breaking in, little happened, which was significant for both operational and design elements.

### **India Experience**

The Indian Army was the first customer to order and receive 18-prs. In theory, India could produce its own guns, although sometimes this was with the help of external suppliers. The Chief Superintendent of Ordnance Factories reported on 20 December 1909 that 61 'A' tubes for

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<sup>176</sup> SUPP 6/66. Annual reports of the president. 1906. 46-47.

<sup>177</sup> SUPP 6/67. Annual reports of the president. 1907. 14.

<sup>178</sup> Ibid. 15.

<sup>179</sup> SUPP 6/66. Annual reports of the president. 1906. 45.

the 18-pr had been sent to India, presumably for building Indian guns there.<sup>180</sup> This was probably the basis for much of the force of 18-prs that India had in 1914.

India also gave the British government some insight into the actual wear of the gun. The India Office in June 1907 wrote asking what the life of an 18-pr was. London replied 6,000 rounds, with the caveat that some might do 50% more than that. This would be the basis of many calculations that would greatly affect the industrial base in time of war, as Woolwich would soon find out. The Committee recommended that six of the new 18-pr designed guns be sent out to units for practice early in 1907. Obviously, the first newly built guns were being built from scratch in 1906 at Woolwich. This meant that by 1914, the RGF had eight years of experience in building and rebuilding the 18-prs.

### Aftermath

The largest unseen impact of the committee might have been the development and professional maturity of its members. Lieutenant-Colonel WFL Lindsay was the commander of the GHQ artillery in 1914. Lieutenant-Colonel ND Findlay, was a Brigadier General and

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<sup>180</sup> SUPP 6/165. Annual report of the president. 1910. 20.

Commander of Artillery, 1<sup>st</sup> Division, in 1914 and was killed on 10 September 1914 in the Battle of the Marne.

The difficulty in understanding the overall strategy for how the Royal Artillery would be used, required an understanding of how the new guns would be used, although certainly in 1907 and even by 1914 this remained vague. This was because of several reasons. First, technology was developing quickly, making a situation where a howitzer would have to work in tandem with the new guns. Second, as so few 4.5-inch howitzers were purchased for the regiment by 1914, time had not passed for new doctrine and tactics to be developed and disseminated. This again resulted from the British understanding of fuzing for high explosive ammunition. Although the 4.5-inch howitzer and high explosive (HE) shell had proven effective at Shoeburyness, the War Office was unwilling to invest heavily in a product that the Regiment of Artillery felt uncomfortable with. It would not be until a crisis forced the gunners to rethink prejudices built into the institutional heritage of their arm that high explosive rounds would return to the arsenal.

## **Conclusion**

The re-equipment of the two mobile regiments of artillery shows the reader that British 'business as usual' worked well when given the time and

resources to effectively execute a strategy. Industry in cooperation with the committee created a gun in essentially two years, with another year for testing. Even more, the entire reequipping only took British industry two years to complete from a stage of initial prototype production to completing all six front line divisions. Although designers would, in hindsight, design a gun that was not well equipped for a battlefield that a decade later required the use of much more high explosive ordnance than was initially perceived, the state of British industry, science, and military culture only allowed for the 18-pr to be built in a way that all were comfortable with. The guns proved to be reliable, long lasting, and usable to those who were not career gunners, all things that would be important. The design features and the competition requirements were indeed correct for what the British Army needed. The two new guns would prove to be a classic of British artillery design due first and foremost to the proper planning of the procurement.

## **CHAPTER FIVE: DESIGN PROBLEMS AND ENGINEERING**

### **WORKAROUNDS, 1900-1914**

#### **Introduction**

Between 1900 and 1914, how Britain built arms changed dramatically. This process was an evolution, as no single event radically changed procedures, although advances in metallurgy, propellants, chemical science, and manufacturing all affected the end product. Guns, even those that were in service, were inherently different systems at the beginning and the end of this period. What follows are general themes of British ordnance from many different angles. These themes are long term observations that drove design, production, and use of British ordnance.

The following chapter discusses technical issues of ordnance from 1900-1914 that compliments the supply and demand chapters. This chapter discusses the overall evolution over all platforms.

#### **Health and Safety**

The driving factor of all ordnance design was to make its operation safe for its crews. The bureaucrats in Whitehall as well as the officers at Woolwich and elsewhere believed that the primary consideration was for equipment that would not malfunction, even in extraordinary



circumstances. This caused difficulties in both design and use of equipment as will be demonstrated in this section.

Although never overtly stated, the cause for this design restriction must have been politicians. As Britain was the only main power in Europe that had a volunteer army, the safety of the volunteers and therefore the regular supply of volunteers was a cornerstone of British defence strategy. If equipment failed, a loss of confidence in the entire system could befall the Government. Both the Royal Navy and the British Army needed ordnance that was reliable, safe, and further down the line of priorities, as powerful as their enemies' ordnance.

### **Wire Wound Guns**

Safety was a primary reason Britain kept wire-wound guns well after everybody else had perfected built-up guns. The thinking followed that if gun crews felt safe, they would be more effective in combat. This was achieved by building up guns through a process first patented in the 1850s and extensively used by Sir W.G. Armstrong in his massive guns built just after the Crimean War (1854-1856).<sup>181</sup>

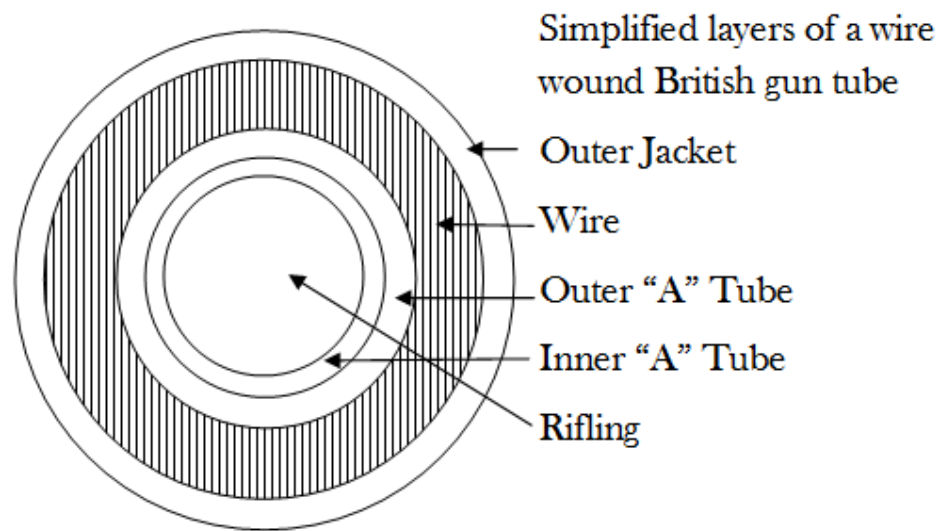
Armstrong entered the market in an era where large guns made of cast or wrought iron had traditionally not been safe. The explosion of

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<sup>181</sup> Marshall Bastable. *Arms and the State*. Aldershot: Ashgate, 2004. 29, 34.

‘Peacemaker’ on USS *Princeton* had occurred just a decade before in 1844, killing two members of the Taylor Cabinet. A radical new design that could ensure safety was a key element of Armstrong’s initial design.

Diagram 1, Wire construction



Wire wound meant that a set of tubes had wire wrapped around their exterior to add compressional strength. The tube was made of several pieces, including the ‘Inner ‘A’ Tube’ that included the rifling and its corresponding ‘Outer ‘A’ Tube.’ Layers and layers of wire were wound around it to add strength. In some guns, some layers were over 100 thicknesses in depth. The wire kept the ‘A’ tubes from exploding on the pressure of the charge, but also, if a shell exploded in the barrel, the wire

would theoretically keep the barrel from becoming a deadly weapon to its users. The wire was itself covered by a jacket or ‘Outer ‘B’ Tube’ as some designs called it, which covered and protected the wire and gave the gun a smooth look. It also added rigidity over the length of the barrel. In 1906 Armstrongs attempted to modify the design, incorporating new technologies (including steel advances), to propose a design similar to the built-up method of other western countries. It was rejected although the single tube was easier to manufacture. The primary reason for not accepting the design was that the safety margin was not in line with British expectations.<sup>182</sup>

Gun wire was not what would initially be considered wire. Gun wire came in a form .06 inches thick, and .25 inches in breadth.<sup>183</sup> It was more like a ribbon than wire, which could cause confusion. For the sake of clarity and historical record, this thesis will use the term wire throughout.

The British wire wound design worked in its stated purpose first and foremost, and of all the reports before the war of damage or incidents to ordnance reported to the Ordnance Committee, there are no casualties due to wire wound gun barrels failing.

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<sup>182</sup> SUPP 6-66. Annual reports of the president. 1906. 93.

<sup>183</sup> ADM 186/220. Manual of Gunnery for HM Fleet. 206.

Cracked guns remaining safe to fire in most cases.<sup>184</sup> ‘In other words, that it should be safe to continue firing the gun, if circumstances require it, after the liner was split, or even cracked circumferentially: all designs passed by the Committee are so figured that this is apparent on inspection.’<sup>185</sup> This became even more important as technology was continually pushed on every point to impart more energy to projectiles.

### **Accident Reporting**

Any accident was investigated by the central committees as well as the Chief Inspector Woolwich, with the results disseminated down, along with recommendations on how to prevent the accident from occurring again. This was a success, as it does not appear from annual digesting of accidents to ordnance in the President’s report that any make and model ever had a repeat incident if the advice was followed. The members, who had been hand-picked from the most competent officers of the Royal Navy and British Army, understood more than anyone that gunners must have confidence in their tools, and the best way to build and maintain confidence in equipment was to have the best safe designs for manufacture. As this was paired with a rigorous inspection process, British gunners felt

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<sup>184</sup> SUPP 6/65. Annual reports of the president. 1905. 1.

<sup>185</sup> Ibid. 3.

comfortable with the weapons taken to war. This confidence was invaluable when it really mattered: in the middle of battle. This though did enable a bit of conservatism in design, especially in breech design, as slower, (but stronger) breeches were used, and once mandated in early designs, continued through later patterns as they became the ‘standard’ designs.<sup>186</sup>

The use of artillery was also constrained for the purposes of health and safety. For instance, in October 1908 a test was conducted to ascertain if artillery could safely be fired over the heads of friendly troops in combat. It was conducted by firing an 18-pr with a fuse set to 0, simulating a misfire. Two rounds were fired, landing 1500 yards and 2,800 yards ahead of the gun respectively. It was recommended that it was not safe to fire the guns within 3,000 yards, or almost two miles, of infantry. This distance would be more for heavy artillery. Faults such as defective munitions, broken drive bands, etc would unduly risk those being fired over.<sup>187</sup>

### **Gun Pressures**

Importantly, for safety reasons the working pressures for British guns were less than the ‘competition.’ Working pressures are defined as the pressure, in tons per square inch, which is produced by the propellant to push the projectile through the barrel. In general, the higher the

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<sup>186</sup> SUPP 6/63. Annual reports of the president. 1904. 2.

<sup>187</sup> SUPP 6/544. Extracts from proceedings Royal Artillery Committee. 60.

pressure, the more energy that can be imparted to a projectile and the more speed that it has when it leaves the barrel, also called muzzle velocity. The faster the projectile leaves the barrel, in general the longer the projectile will fly before landing, based on Newtonian physics and the Second Law of Motion. There was a British requirement on almost all guns to limit pressures to 18 tons in pounds per square inch at the breech. This single requirement drove every other aspect of how British guns were designed and used, including gun design, propellants, and projectiles. Although experiments were conducted after 1905 to raise it to 20 or even more tons per inch, by 1914, the standard remained at 18 tons per square inch. Working pressure was a safety measure, but it was also used as a primary way to control what might be the biggest worry for British, and especially naval, ordnance officers: gun longevity.

### **Health and Safety Past Guns**

It is not only in the design of guns themselves that health and safety concerns were apparent. In June 1905, Mr Arnulph Mallock recommended using ‘artificial ear drums’ to protect ears from the blast, replacing the cotton in regular service. (Mr Mallock was a civilian member of the Ordnance Committee from 1903–1907 as well as a Fellow of the

Royal Society.)<sup>188</sup> These would be ear muffs made of drums with India rubber coating. In the end Mr Mallock's design was not accepted because they were seen as inferior to Elliot's protectors which had been approved just a few years earlier.<sup>189</sup> Many modern conceptions of the Edwardian time period as being indifferent to personal safety or injury simply do not bear close scrutiny at least when the concerns of those employed by the Government were concerned.

### Gun Longevity

Gun longevity increasingly became an important aspect of governmental/industrial relations. It also became a driving factor in design technical trade-offs. The increasing worry about erosion of the rifling of the barrel had a great follow-on effect on the capacity of industry to reline guns. A longer life measured in rounds fired before reaching the end of being militarily useful meant less need to reline, and more availability of both the gun and the ship, in the case of the Royal Navy. A longer life would also allow a specialized industrial policy that utilized Woolwich alone to remain rebuilding guns, and allow Vickers and Armstrongs as well as any other new supplier to build new guns, as noted in the Murray

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<sup>188</sup> SUPP 6/67. Annual reports of the president. 1907. 565.

<sup>189</sup> SUPP 6/66. Annual reports of the president. 1906.851-852.

Report in Chapter Two. Guns with better rifling were also more efficient in the use of ammunition, as the shots were more consistent and accurate for longer periods. Therefore, the gunner should have been able to hit the target more often, thus saving ammunition.

One of the easiest ways to increase gun life turned out to be the research and development of better drive bands, or obturator bands as they were sometimes called. Driving band design was difficult because it had to strike a medium between giving satisfactory shooting in worn barrels and not excessive pressures and therefore wear in new barrels. A study in 1906–1907 had already limited drive bands to copper, cupro-nickel, and wrought iron. The latter tore up the lands of the rifling so much it was considered unfit for service.<sup>190</sup>

The most pressing technical issues of the 1901 report were the need to make better obturator bands as the guns were, with advances in propellant, creating pressures that were more powerful, and could not be supported by current versions.<sup>191</sup> Drive bands were thought to be where much of the wear of a barrel were created until about 1905. The drive bands, served two purposes. First, they were a soft metal that could grip rifling and impart spin without damaging the barrel. Second, they acted as a gas check that allowed for a more efficient use of energy from the gas of

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<sup>190</sup> SUPP 6/67. Annual reports of the president. 1907. 25.

<sup>191</sup> SUPP 6/61. Annual reports of the president. 1902. 2.



the burning cordite to the projectile. The improvements in shells could, in certain guns, exponentially increase the life of the barrel by changing the metallurgy of the band between copper, bronze, and other metals as well as the shape of the band itself and its position on the shell.

### **New High Velocity Guns**

As new high velocity guns became more widespread, especially in the Royal Navy, it was discovered by Admirals Chase, Parr, and Foote that the middle sections of the length of the barrels were not coming into contact with the drive bands on the shell in worn guns.<sup>192</sup> New bands were needed to fix this and a drive band was designed, proofed, and accepted to fix this issue. The larger problem would not be discovered until several years later, as will be discussed later.

There were other factors that had to be looked at other than friction in the wear of barrels. The Ordnance Committee as true bureaucrats were worried about many more factors than simply building the best gun that money could buy. A 1903 note from the 6-inch Mark VII project lays this out. The Committee worried how higher velocities from new propellants would affect the increased ballistics, the muzzle velocities, and the life of the rifling. An increase in velocity decreased the life of the barrel from

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<sup>192</sup> SUPP 6/65. Annual reports of the president. 1905. 4.

2,000 rounds to just 400, with the increased range and power that could be associated with such an improvement.<sup>193</sup>

### Gas factors in high velocity guns

After about 1903, some British technicians within Government started coming to the conclusion that excessive barrel wear might not be exclusively a product of driving bands wearing worn barrels through friction, but also that the gases produced by the cordite might also have something to do with it. The speed of the gas and flame appeared to be scoring barrels in the new high-velocity guns that were becoming the current direction of design in British weapons. To work, driving bands had to be as thick as the thickness of the rifling, or they would not be a gas check, and would lead to inefficiency and inconsistency. Therefore, every driving band should grip the entire thickness of rifling for the entire length of the barrel. Hot cordite gas was created at speeds of anywhere from 1,000 to 3,000 meters per second, or roughly 3,000 to 9,000 feet per second.<sup>194</sup> As well, copper fouling left from the previous projectiles would create friction, which converted to heat and caused drag in the barrel as well as decreased muzzle velocity.<sup>195</sup>

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<sup>193</sup> SUPP 6/62. Annual reports of the president. Note: Appendix 1903. 93-94.

<sup>194</sup> ADM 186/220. Manual of Gunnery for HM Fleet. 216.

<sup>195</sup> SUPP 6/60. Annual reports of the president. 1901. 52.

Mr Arnulph Mallock, as a civilian member of the Ordnance Committee, conducted experiments in 1905 and based his theory of erosion upon the primary cause being temperature and velocity, and not steel composition or driving bands. He based this on maximum velocity, which was in excess of projectile velocity, and therefore, the metal could not cause erosion, and it must come from somewhere else. In this particular case, he surmised that erosion came primarily from escaping gases. This was to be proven through a new design for a 7.5-inch gun which was to be a test bed for all future guns.<sup>196</sup>

Nothing can be found in the secondary sources that mentions this issue, and, it appears in not one of the corporate histories. This is for good reason, as almost all of the research was conducted at Government-owned laboratories and ranges with exclusively governmental funding, and technical reports were put in a 50-year classification. This information thus was incorporated into the supply chain through design changes and specifications given to manufacturers only at the end of the design phase for building to the specification.

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<sup>196</sup> SUPP 6/65. Annual reports of the president. 1905. 11-12.

### Other barrel wear issues

Because of all of these reasons, this is the most understudied part of the story in barrel wear. When asking for new 9.2-inch guns in 1903, there were designs for heavier, 20-ton breech pressure guns, although the Chief Inspector Woolwich was having a difficult time with managing ballistics. His research indicated the discovery of a previously unknown physical barrier at about 3,000 f/s in muzzle velocity. The Chief Inspector Woolwich thought this barrier was due either to the driving rings of copper not being able to manage both the pressure for a proper gas check as well as the increased torque, or the increase in friction being an exponential factor that simply had eluded scientists. Nonetheless, Chief Inspector Woolwich experimented with a cupro-nickel drive band, but three of the four failed by breaking upon firing.<sup>197</sup> This increased muzzle velocity would take a lot more time to work out, and in the end, the consensus was to drop pressures and work on increasing the weight of the projectile in lieu of speed.

Major Minchin, Royal Artillery, was the British expert on rifling; ‘working out curves of rotation, pressure for various guns, and suggesting modified grooves and various twists’<sup>198</sup> Rifling was an ongoing and

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<sup>197</sup> SUPP 6/62. Annual reports of the president. 1903. 13.

<sup>198</sup> SUPP 6/60. Annual reports of the president. 1901. 4.

expensive endeavour, with uniform versus increasing twist being in the foreminds of the committee. British officials performed tests through a head to head format, ordering one of each at initial trials as well as re-rifling with new grooves in a wide array of gun sizes and velocities. Rifling always entailed a balance between wear, muzzle velocity, range, and accuracy.<sup>199</sup> More research needs to be done on how the design of rifling affected the overall wear and accuracy of guns, but as one of the more technical aspects, it must wait for its own study.

Poor design on the other hand might be the most well-known cause of wear to historians. The 12-inch naval and coast artillery guns were notorious for ‘choking.’ This was caused primarily by the inner tube sliding slightly forward, and building up a slight amount of metal that could only be repaired by boring it away. Behind closed doors, the Government put much of the blame squarely on the Vickers design, which none of the corporate historians mention, and is not apparent in the corporate financial records. The problem was eventually fixed by a two-pronged attack from the Ordnance Factories inspecting physical examples of failed barrels and Vickers fixing the design once its flaws were discovered by the Royal Laboratories and Gun Factory. This process will be discussed in detail later.

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<sup>199</sup> Ibid. 4–5

## Consistency

A final piece was the battle for consistency. This was shown by the discovery of how ambient temperature in the new cordite greatly affected the internal pressure, accuracy, and range of projectiles. Showing a surprisingly modern and scientific approach, the government set a standard temperature with which to design barrels to and base range tables on. This forced interesting and significant changes, including the more widespread use of electricity on board ships so that the magazines could be kept at a constant, air conditioned temperature.

Tests were conducted on a 4-inch Mark VII gun to try to get more consistent shooting. What might be most interesting is that stick cordite was seen as a much more consistent product than the powdered propellant used by all other western countries.<sup>200</sup> Also interesting is that British designers wanted to design a muzzle break, but could not figure out how to do it. This would take until after the First World War to come to fruition. The muzzle blast was thought to have disturbed the flight of the projectile. It was discovered after inspection of the driving band that the fault lay in the inconsistent burning rate of cordite.<sup>201</sup> Essentially, it was a point of discussion as to where the projectile was in the bore when the cordite was

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<sup>200</sup> SUPP 6/163. Annual report of the president. 1908. 84.

<sup>201</sup> Ibid. 83.

fully burned. As the propellant reached its fully consumed state at different places, the speed and pressure at the muzzle was inconsistent. It was most desirable to get the powder burned as close to the chamber as possible, but the reverse had to apply to get the high muzzle velocities needed in modern guns.<sup>202</sup>

Longevity of the barrel also depended on proper maintenance of the guns. While not being used naval service guns were to have their bores lacquered whilst in long-term storage. Guns on board vessels were to be coated with a mixture of 95 per cent mineral jelly and 5 per cent beeswax in all climes, and land service guns were to continue to be coated in oil. Oil was better than lacquer for the purposes of land storage.<sup>203</sup>

As can be seen, there were many variables that affected the life of a gun. Some of these could be engineered or designed out, while others were by-products of other trade-offs.

### Cordite

Cordite or corded ballistite, was the single largest factor in gun longevity. Although specifics of its manufacture and the business surrounding it are not within the scope of this thesis, a section has to

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<sup>202</sup> Ibid. 84.

<sup>203</sup> SUPP 6/60. Annual reports of the president. 1901. 67.

mention how the propellant affected the calculus of balancing capacity and needs within the ordnance industry.

Cordite was a low explosive invented late in the nineteenth century as the leading British variant of the new nitrocellulose and nitro-glycerine powders invented by Western powers. It was a successor to black powder based propellants that had been used for centuries. Its appearance looked not dissimilar from a cord about the shape of round noodle pasta; hence the name. As a low explosive, it was designed to burn at a prescribed rate, thus having a controllable burn in gun barrels, which would create gas that would push the projectile out of the barrel. A high explosive on the other hand does not burn, but explodes due to its faster release of energy. The understanding that a propellant pushes an object to perform work is one of the key visualizations in understanding internal ballistics, or, what happens inside a barrel when the propellant is ignited.

One of the primary issues with cordite was that it burned hotter than the melting point of the steel. In the less energetic black powder this was not an issue. The heat was not a pressing issue in smaller ordnance. Larger guns had inherently more pressing issues, as they required larger masses of propellant as well as possessing longer burning times, as the barrels were



longer and the initial inertia was greater to overcome on the larger projectiles.<sup>204</sup>

Nitrocellulose powder as used in other western countries was determined unacceptable in naval ordnance by the Explosives Committee in tests between 1900 and 1903.<sup>205</sup> This determination meant that naval guns would be forced to use cordite for all uses, and meant that all powder would have to be sourced from the UK, as the only companies using the process were domestic.

The thickness of propellant could also be tuned to best get the desired internal ballistics necessary for the particular gun. A longer barrel meant that more burning time was available, while thinner strands usually meant less burning time as required by smaller guns.

### **New Propellants**

The problem with the original Mark I Cordite was that it was not friendly to gun barrels. The life expectancy on some designs was barely 100 rounds. This meant that guns were not able to be used for practice with full cartridges, and that guns had to be replaced frequently. Part of the solution was to rethink the recipe for cordite so as to increase the longevity of guns.

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<sup>204</sup> ADM 186/220. Manual of Gunnery for HM Fleet. 94.

<sup>205</sup> ADM 1/7761. 1904 D.N.O. Director of Naval Ordnance In-letters 1904 Nov.-Dec. 5.

This was achieved with Cordite MD (i.e., Modified Design) a chemically improved version, and later, Cordite MDT (i.e., Modified Design Tubular) which was a tubular, hollow stick, which allowed for a more controlled burn rate. These powders would open up the gun designers to gain performance without having to worry about constant relining of barrels.

In 1901 Cordite MD was authorized for naval service, although it would take time for each gun pattern to be approved for the new propellant. Not all powders had the same specific gravity, and this new MD powder was less dense than the older Cordite Mark I. The scientific knowledge of cordite developed rapidly, and by 1902 the designers at Woolwich were able to calculate the burn rates of all cordite powders and estimate how far from the muzzle each charge would burn. This was a key element in designing larger and more powerful guns.

The new cordite had a great and positive effect on the wear of the guns. The chart below demonstrates the difference between the old Mark I Cordite and the new Cordite MD on certain guns. By 1905 the superiority of MD over Mark I Cordite in regards to erosion was well marked. There still is not enough evidence to confirm when Mark I was pulled from service.<sup>206</sup> In addition to ordinary service, Cordite MD wore guns much less

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<sup>206</sup> SUPP 6/65. Annual reports of the president. 1905. 13.

than Cordite Mark I in proofing, when the pressure curves were more aggressive<sup>207</sup>

The War Office and Admiralty based their assumptions for wear rates on the compilation of research and data collected by the Superintendent of Research at Shoeburyness as well as calculations by the Chief Superintendent of Ordnance Factories and his staff at Woolwich. The following table was baselined to 1910 specifications for cordite and design, although it can be assumed it is generally acceptable for the entire span of study within probable error.

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<sup>207</sup> Ibid. 110.

**Table II**<sup>208</sup>

Barrel life by powder – units are in full charge shells

<b><u>Gun model</u></b>	<b>Cordite Mark I</b>	<b>Cordite MD</b>
13.5-inch Mark V		450
12-inch Mark VIII	220	500
12-inch Mark IX	130	280
12-inch Mark X		280
12-inch Mark XI -XII		160
9.2-inch Marks IX - X	125	450
9.2-inch Mark XI		300
7.5-inch Marks I, II, V		600
6-inch Mark XI		1000
6-inch Mark VII (29pound)		1200
6-inch Mark VII (20-23)	900	

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<sup>208</sup> SUPP 6/165. Annual report of the president. 1910. 35.

6-inch QF	1200	
4-inch BL Mark VII		1200
12-pr QF 18-cwt		1200
12-pr QF 12-cwt	900	

This scientific research also was used to make sure consistency of product to operators. Powder had quite a bit of inconsistency between batches. An example of this is described in an interesting case. Two batches, Batch 69 and Batch 31 were investigated, and although they were the same powder type, simply through nascent differences in manufacture, created errors. For instance 69 produced 2674 f/s and 17.5 tons, whilst 31 produced 2705 f/s and 17.8 tons breech pressure in the same proof gun. These errors had to be calculated for each batch of powder to tune the cartridges they would be used in. Humidity, temperature, and other phenomena had a great effect on the velocity, accuracy, and various other characteristics of guns, especially long flight naval projectiles. Arguably the most understudied of experiments was the experiments in temperature to cordite. In tests of the 4-inch QF gun, it was discovered that 10 degrees difference in temperature Fahrenheit resulted in changes of .36 ton

pressure and 18 f/s. In the 4.7-inch gun, this was 22.86 f/s and .19 tons.<sup>209</sup>

In naval guns changes were even more pronounced. In addition, a change in temperature from 65 degrees to 80 degrees Fahrenheit equated to a change in initial velocity from 2547 to 2614 f/s based exclusively on temperature.<sup>210</sup> Thus, assuming a 20 second flight, with consistent and equal reduction due to air resistance, the batch difference would cause an over/under shoot of 600 feet, and 15 degrees temperature would cause an over/undershoot of 1400 feet.

### **MDT Cordite**

1908 saw strip cordite as the primary propellant being replaced by tubular cordite, as strip cordite was inconsistent in ignition. ‘Meanwhile our knowledge of tubular was in its infancy, and we had to fall back on cords.’<sup>211</sup> This was a significant step, as industrial concerns about being unable to make this powder, as well as MDT, forced gun designers to utilize the older powders even though designs existed for newer breech designs utilizing better powders with better results. In hindsight this point of failure was an area that should have received more scrutiny and investment.

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<sup>209</sup> SUPP 6/163. Annual report of the president. 1908. 86.

<sup>210</sup> SUPP 6/62. Annual reports of the president. 1903. 50–51.

<sup>211</sup> SUPP 6/163. Annual report of the president. 1908. 84.

MDT did continue to have tests conducted upon it, although there was not enough to actually bring a gun using the propellant into production. A test in 1914 with a 6-inch Mark XII and one with a smaller MDT chamber showed that a smaller MDT chamber was not enough of a difference to warrant the change.<sup>212</sup> Apparently the wear in the MDT gun was much more significant after 239 rounds.<sup>213</sup> This discovery required massive investment to fire at experimental levels several thousand rounds, costing precious powder, projectiles, laboratory space and labour as well as range space which was limited even in peacetime, and almost impossible to find in wartime with the needs of proofing guns after relining.

Life of rifling tests were also conducted on 9.2-inch Mark IX and X guns. These guns were used for heavy cruisers as well as coastal artillery guns for many forts and ports throughout the Empire. Testing wear often was conducted to ascertain wear based on the charge size of cordite. In this case, size 40 prolonged the life of the barrel by 25 rounds but this was due to loss in muzzle velocity caused by smaller sized cordite. In the end, the Ordnance Committee rejected size 40 cordite for use.<sup>214</sup> This was representative of much of the research done at Shoeburyness, finding the correct powders to match the characteristics of the guns themselves. It was

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<sup>212</sup> SUPP 6/169. Annual report of the president. 1914. 257.

<sup>213</sup> Ibid. 258.

<sup>214</sup> SUPP 6/60. Annual reports of the president. 1901. 5.

an expensive process though, as usually the guns would need to be relined after the experiments, if they could be used at all, and the shell and powder used in larger guns could easily have a total cost in excess of £10,000. It was obviously worth it though to contemporaries, who did not seem to shrink from costly experiments if the benefits were potentially large.

### Old Guns, New Propellant

Early guns built in the 1880s and 1890s had high failure rates once they were converted to the cordite powder, which they were not designed for. For example a 9.2-inch Mark V gun on board *Warspite* cracked its liner to a length of 175 inches. This 1886 Elswick-made gun was one of the pre-annealed guns. Annealing was a process introduced into commonplace manufacture of British guns between 1898 and 1900 and by the accident the specification for manufacture had been changed to allay this problem.<sup>215</sup> *Warspite* was sold off in 1904, so these guns were not only obsolescent but obsolete by the time of the incident, which might have led to the decommissioning. This mass of cracked guns made before annealing furnaces were used was probably the underlying cause for many obsolescent ships being taken out of commission from 1902–1905. Many of these older guns, if actually used in battle with cordite, had a strong

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<sup>215</sup> SUPP 6/62. Annual reports of the president. 1903. 91.



chance of cracking or even worse when fired at combat rates and temperatures. It appears that the Admiralty believed it would be easier to decommission vessels instead of redesigning an obsolescent gun to take new powder and update the manufacturing techniques. In the middle of 1902 a call was sent to manufacturers to ascertain what could be done to rebuild or alter all guns to get greater power. In every case, the cost of rebuilding was too costly, although new powder charges were created, and extensive testing was started with composite charges which were made up of several different sizes of powders that offered a different pressure at different points in the firing cycle.

For the navy, the increased weight in charge had to also take into effect the abilities of the on-board hoists to get particular sizes and weights to the guns from the magazines.<sup>216</sup> This investment was not a justifiable cost to Parliament, reeling from the immense costs of the recently concluded Boer War. The introduction of Cordite and Cordite MD allowed designers to step back and rethink what the future of warfare was as well as making hard decisions on fleet recapitalization.

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<sup>216</sup> SUPP 6/61. Annual reports of the president. 1902. 5.

## Reserve Guns

Eventually, guns wear out. When that happens, they need to be replaced, and the most efficient way is to keep an amount of guns in reserve that can be used to replace them. In the case of the Royal Navy, one of the greatest state secrets was the size of the reserve pool of guns. This secrecy went even as far as Parliamentary permission being used at least as far back as 1888 exempting it from publication in the *London Gazette*, the only such exemption that is known to have been given in this period, and tight secrecy was imposed on manufacturers and Parliament as to how many guns were purchased in any given year.<sup>217</sup> The secret was of the utmost importance because of the intelligence that could have been garnered about the percentage of guns that could be replaced after a battle, the calculated wear life based on the amount of reserves, and weaknesses in multiple segments, including industry and metallurgy.

The Boer War had a significant effect on the designs of ordnance that would subsequently be produced. Officers came back with very specific lessons learned. Reserve guns became the largest takeaway in naval backdoor discussions during and after the war. The Admiralty felt that they were being cut out of industrial capacity: whether this was indeed true or

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<sup>217</sup> WO 395/1. Annual Reports 1873-1903. 10.

not is beside the point. Clive Trebilcock certainly supports this idea in multiple sections of his work *The Vickers Brothers*. The conclusion that Admiralty came to was to increase the ratio of reserve guns held. The Royal Navy felt that if they had actually to engage, there would have not been an opportunity to remanufacture barrels. This forced the Royal Navy to seriously analyse the amount of reserve tubes they ordered after the war ended. The final number, as decided after the Boer War was one reserve gun to every five mounted on warships. This meant that, in the event of action, some guns would be replaceable nearly immediately, although the reserve gun ratio was only part of the calculation for the navy.

The policy that was adopted encompassed the needs of the Navy irrespective of what the Army was doing. In addition, guns were sent abroad to be forward deployed. This meant that the Admiralty was only willing to send ships whose gun classes were already forward deployed. In places like Australia and the Pacific, it meant that Dreadnoughts with their 12-inch guns would not be sent, because the largest spare tubes east of Malta were 9.2-inch guns.

In addition, there was a chokepoint in capacity of both Shoeburyness and the water transport between Woolwich and Shoeburyness. There was only one barge available to move the heavy guns,

and it ran on a limited schedule.<sup>218</sup> As this was the case with Shoeburyness, it can also be assumed that naval guns could only be transported to naval bases, including Portsmouth, by barge. By 1902 it does not appear to have been possible to move naval guns by rail. In addition, at Shoeburyness, in the autumn, winter, and early spring the weather, especially fog and low-lying mists made firing proof shots difficult for both clear sight and recovery. The 13.5-inch Mark V guns were wholly unsuited for over water shots as their range exceeded Shoeburyness safety distances. This fog issue affected guns of four inches and above, which meant that in peacetime the rate of proofing was limited due to safety concerns.<sup>219</sup>

### Strategy of Reserves

Strategically, the number of reserve guns also had the direct effect of allowing the commanding admiral of the battle fleet to engage after a battle much sooner by replacing the worn and damaged guns from reserve instead of having to wait for industry to build the replacement. To replace all guns in this period would very probably have taken even a fully engaged British industry 18-24 months to fully reline the necessary articles. This would have put the willingness of the commander to engage in a protracted

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<sup>218</sup> SUPP 6/61. Annual reports of the president. 1902. 1.

<sup>219</sup> SUPP 6/167. Annual report of the president. 1912. 121.

battle in doubt no matter the enemy. The life of a barrel and replacement tube numbers therefore together made a much more important calculus of how the battle fleets would be used than has ever been put forward.

As a note, when two guns sit in a naval turret, the breech blocks swing out. These are called left and right guns. In almost all cases, left and right guns are interchangeable (although sometimes requiring a reproof for accuracy) with each other, thus making them much more usable in reserves.<sup>220</sup> Of course, this is not a problem in field and army guns, as they are single mounted.

When guns were used for experimentation, they often were pulled from reserve gun pools. The Ordnance Committee in 1906 requested new reserve guns with all the same technical properties as then 12-inch Mark VIII and IX guns to replace those being pulled out of stock for experiments. The replacement guns would have the same properties, but incorporated new cannellured rings on the shoulders of the inner tubes and nickel steel construction. This experimentation was part of an indication for nickel steel that is talked about in the new materials section below. Another example of this occurred in April 1908.

Two guns of 12-inch Mark VIII were relined with a new liner without the steps forward. The two proof shots caused a slight bore post-

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<sup>220</sup> SUPP 6/63. Annual reports of the president. 1904. 25-26.

proof that exceeded the specification in a few places, but Chief Inspector Woolwich suggested handing these over to plate and cordite testing, although importantly, 'DNO 20.10.08, however stated that they were required for issue to the Fleet.'<sup>221</sup> The demonstration in 1908 showed that the immediate needs of the service always came before long-term research.

The replacement strategy was intended to allow for experimentation and improvement as well as for a rapid replacement if necessary for any spare guns. One of these older guns was replaced at just 130 shots.<sup>222</sup> These new reserve guns did not fit the standard specification for the class of boat. Although ballistically they might be identical, the manufacturing or buildup of reserve guns was sometimes slightly different. In rare cases, this was so significant that the tubes could only be used for single identified vessels. This inflexibility meant that some reserve guns simply were not as valuable as the tubes they were to replace. The trade-off was that the reserve was often used for experimental purposes and expanded knowledge while also being available if necessary.

As part of the process to speed up relining, between 1901 and 1904 Woolwich reworked how it removed liners. Earlier, it bored out the old tubes, but sometime in or before 1904 it went to a new system whereby it

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<sup>221</sup> SUPP 6/163. Annual report of the president. 1908. 21.

<sup>222</sup> SUPP 6/65. Annual reports of the president. 1905. 10-11.

heated the barrel and ‘tupped it out’, which gave much better results.<sup>223</sup> The constant maintenance of Woolwich as the centre for wartime repair meant that key investment were made that could get guns back in the field much quicker and efficiently than by starting from a dead stop with unskilled employees. Without Woolwich, the refurbishment of guns for all services would have been unavailable.

### Naval Reserve

Armaments for the Royal Navy were limited to a great extent by a limitation of infrastructure, not in the gun-making industry, but in the capacity of the public and private shipyards in dry docks and building slips required for the new and better classes. In the post-*Dreadnought* navy, capital ships had a limited number of guns. These guns were larger and more powerful, and therefore much more complicated to build, than had ever been seen before, but the number of primary and spare barrels was finite. By 1905 it was the Admiralty’s policy to order one great gun for reserve in four being mounted.<sup>224</sup> In addition, the navy saw the lessons from the war in South Africa as the next war would possibly tax industry more heavily than before, and had a larger reserve ordered. They especially

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<sup>223</sup> SUPP 6/63. Annual reports of the president. 1904. 104.

<sup>224</sup> Hansard *HC Deb 19 July 1910 vol 19* Statement by Lord Beresford. 1140.

feared, as a 1903 report quoting an earlier analysis by Sir Henry Brackenbury showed, a war that would require massive expenditure and a heavy burden on industry from both services.<sup>225</sup> The same report continued that Woolwich would be overly taxed from the perspective of transportation with raw materials coming in, finished goods leaving, and the requirements of inspection. The report continued that this single point of failure would certainly in the event of a new war paralyze the services, and that a new depot for the storage of warlike goods was necessary to mitigate this. Four years later, the Murray Report would by policy limit this stress point to just six months when the arsenal would be the primary manufacture point, and after this, it would exclusively become a repair and inspection point. Finally, Brackenbury's most far-reaching opinion was to learn from the army's logistics mistakes in war, through standardizing the munitions used. This could have been seen as lending an impetus to the *Dreadnought* style of limiting bores of guns carried on ships.

Some guns were ordered in numbers outside the normal one to four ratio. Some models were much more aggressively, or, the Admiralty at least perceived them to, which caused reserve orders well in excess of the usual rates. For instance, the 7.5-inch Mark II/V guns made for the *Warrior* Sub-Class and *Minotaur* Class armoured cruisers had a

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<sup>225</sup> ADM 1/7686. D.N.O. Director of Naval Ordnance In-letters 1903 March-April



combined need of 46 guns, four-in-four and three-in-ten respectively. The Army Contracts Office purchased 38 Mark IIs and 46 Mark Vs spread across Vickers, Armstrong, and the Royal Gun Factory.<sup>226</sup> This output demonstrates that naval ordnance use was not an exact science, and if given the choice, buyers would hedge on the side of caution. As well, if the wear rates were indeed as aggressive as it appears from the purchasing records, the Admiralty would not stay with underperforming guns. The 7.5-inch gun was not mounted on any subsequent class as a primary or secondary armament, although the gun's demise probably had as much to do with the changing design requirements in the post-Dreadnought navy as with any particular failings of the design.

By 1910 the Admiralty had increased its reserve guns as the larger guns were brought to production and mounting, especially the 13.5-inch guns.<sup>227</sup> This had a great effect due to the increased barrel length of the 12-inch Mark IX, X, and XI guns, which were 40, 45, and 50 calibres, respectively. Over a span of under a decade the same shells increased muzzle velocities by over 400 feet per second. The increase extended exponentially the range at which the great guns could engage targets, as well as the force imparted on targets by the projectiles. A major design feature

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<sup>226</sup> WO 395/2-3 Report of Army Contracts 1904-1913; *Annual Accounts of the Ordnance Factories: Report of the Comptroller and Auditor General, 1906-1908*. (London, UK: House of Commons, 1908)

<sup>227</sup> Hansard *HC Deb 19 July 1910 Vol 19* Statement by Mr. McKenna. 1143.

for the 13.5-in gun designed for the super dreadnoughts of the *Orion* and subsequent classes, was to maximize force by building larger barrels which also exponentially increased shell size. An increase in one and a half inches at the bore increased the projectile from 850 to 1400 pounds, without loss in range.

It was one thing to manage the reserve component of the fleet at home, where the Home Fleet was within a barge delivery of a new gun, but the needs of imperial defence were quite another. The Admiralty was forced due to its expeditionary nature to pre-position guns at strategic points within the empire and around the world. The Admiralty's strategy was to send guns in advance of any deployment, although this was not always possible. For instance, when a cruiser was deployed to the Pacific, spare tubes were sent as well, usually to either Sydney or Hong Kong, as these were the only naval bases that were able to sustain such a large vessel. Admiralty policy also tended to send the vessels with the newest guns to the furthest places in imperial defence as they would have, in all likelihood, the least need for new barrels for the longest time into the future. This strategy was a limiting factor in what vessels could be sent where, and essentially meant that the Pacific in particular would be left in time of war without a capital ship in 'home waters'. This was a project that had been policy since

at least 1900, and was a well-entrenched policy for how the fleets would be used in wartime.<sup>228</sup>

In addition, the Admiralty spent large amounts of treasure and capacity pre-positioning smaller guns, 6-inch and 4.7-inch guns for use on merchant vessels, which could be turned into merchant cruisers in time of war. 120 4.7-inch mountings were at Chatham, Devonport, or Portsmouth by February 1912, with an additional 48 pre-positioned in Sydney and Hong Kong. These were to supplement the 24 reserve 6-inch mountings which would be mounted on larger merchant cruisers.<sup>229</sup> These by May 1914 were destined in particular for the *Lusitania* and *Mauretania*.<sup>230</sup> These vessels appear to have no reserve guns made for them, as, these medium-calibre guns had average lifespans much longer than the ammunition that was carried and the likely limited firing as well as limited campaigning that these guns would ever be required to participate in.

The ability of the Navy to accurately place a shot had always been an art, and as ranges increased this became increasingly difficult. As with the army, the naval planners also had realized these limitations. For instance, in the 1910 naval gunnery book the maximum range of the most modern

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<sup>228</sup> ADM 1/7761. 1904 D.N.O. Director of Naval Ordnance In-letters 1904. 4.

<sup>229</sup> ADM 186-182. Quarterly appropriation list of gun mountings for breech-loading quick-firing and machine guns, February 1912. 36, 42, 45.

<sup>230</sup> ADM 186-194. Quarterly appropriation list of gun mountings for breech-loading quick-firing and machine guns, May 1914. 37.

12-inch gun, the Mark XI, was 20,200 yards in 34.15 seconds. This was an increase in just 10 years from the Mark VIII from 14,000 yards with a flight of 28 roughly seconds. These were significant challenges and advances in a short time, and even more impressive considering that they were firing the same shell.<sup>231</sup>

In 1908 it became publicly known that the German Navy had started placing large orders for vessel armaments with Krupp, the foremost German armaments manufacturer. This was taken many ways in London. The largest effect was the 1909 Naval Vote that authorized immediately four battleships and several battle cruisers with the option of up to eight battleships. With each ship carrying new 13.5-inch guns and ten barrels each, this was a massive boon for the industry, which had been hurting from the lack of orders. The 13.5-inch breach loading guns were 50 calibres in length, giving a full length of 56 feet excluding the breach and mechanism. This massive order was also the first order to apparently be placed by the Admiralty contracts office, and not the Army.

HMS *Dreadnought* in and of itself did not represent a leap in ordnance. The guns used were the 12-inch Mark X, a 45 calibres naval gun that had been used in the last run of the *King Edward VII* class vessels. What *Dreadnought* did represent to armourers was an exponential

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<sup>231</sup> ADM 186-181. 'Range Tables for His Majesty's Fleet 1910'. 29, 119.

increase in the numbers of guns needed to commission each vessel.

Weight in both armaments and broadside would require more big guns of the largest sizes from the trade. This increase in demand in quantity required larger outlays in Trade plants for both the increase in machinery, and for the guns themselves, as they grew in length and weight until the pinnacle design of 15-inch guns in 1913. This increased weight required larger and larger cranes, lathes, forges, presses, and buildings, causing vast and ever increasing outlays in capital investment as well as competent, world-class labour to operate and manage it effectively. It would be this increased heavy capacity that would become integral to any upsurge if conflict arose, especially if it involved a Continental power.

### Capacity

What might be the most important hidden issue of the period between 1900 and 1914 was the increasing use of second tier suppliers. This would include manufacturers who could not build completed guns, but supplied components, mainly in the form of the finished forgings or tubes, to the five primary suppliers. These suppliers would understandably be key in any time of crisis. One of the few benefits of the British type wire wound gun was that the base materials were theoretically smaller, and did not need the massive investment in plant to supply the much lighter, albeit

just as precise, inner ‘A’ tubes necessary for initial building as well as relining. It should not be a surprise that this was most important to Woolwich, as the Royal Gun Factory was the main relining facility in Britain. Unfortunately, little is known about many of these firms, and the Government records are almost wholly lacking in details of these smaller suppliers, although, to mention a few, they included Beardmore, Cammell, Brown, Spencer, and Firth. The industry in 1910 was considered as follows: Beardmore, John Brown, Cammell, Laird & Co, Armstrong, Whitworth, Firth, Spencer, Taylor, Vickers, and Darlington.<sup>232</sup>

The small firms left even less of a physical paper trail than the large firms, and a full study of this sector is unfortunately not within the scope of this study, although economic and business historians would gain greatly from a full study of the topic.

Calculating the industrial capacity of Britain’s gunmaking trade is difficult even today. Certainly by 1906 at the latest the government was taking deliberate steps to ascertain what exactly capacity was. This was led by the Admiralty, as the service had been unpleasantly surprised during the late war in South Africa. A committee was formed to not only look at the

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<sup>232</sup> SUPP 6/166. Annual report of the president. 1911. 62.

state of their industry, but to look closely at a weak point in the system:  
inspection.<sup>233</sup>

### Inspection

Inspection was the Government's final check on guaranteeing consistent quality through the supply base. It was a proven way of confirming interchangeability of products not only from gun to gun, but also from one manufacturer to another.

The actual mobilized capacity of Britain was a concept that doesn't survive in records. No records were probably ever created. The concept that a supply base (outside Woolwich) be kept ready for the possible use of the Government was a concept that was unknown in this period. Even in shipbuilding it was not considered important due mainly to a new class being built if not every year, certainly every few years. The advances of technology did not make having a static industrial line efficient or desirable, as obsolescence was a real problem. The period from 1900 to 1914 was awash with evolutions in weapon power, size, and construction. Historians must take care in understanding the topic without modern influences.

Therefore, the capacity of Britain's ordnance industry in 1914 was not dissimilar from what it had been a decade before. Certainly the

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<sup>233</sup> WO 33/2960. Report of the Committee appointed to consider methods of inspection and delivery of naval ordnance and naval ordnance stores.

capacity for larger ordnance had been invested in, but the capacity of output in quantity was on comparable terms. The Trade had not built a field gun since at least 1908, and the naval reserves were being ordered and delivered at the same time new ships were initially being fitted out. There was no talk of expanding actual production capacity, and if anything, there was an overcapacity, especially in smaller ordnance, which had been created with the entrance of Coventry Ordnance onto the scene in 1905. Certainly naval gun capacity could equal warship building capacity, which was the greatest limiter of naval orders, and after 1907 the British Expeditionary Force of the Haldane Reforms was not planned to expand beyond the moderate reserves already received. Of the five plants engaged, Armstrong's Elswick plant could produce everything in the British arsenal, as could Vickers River Don Plant in Sheffield. Beardmore on the Clyde in Glasgow was making an order for the new 15-inch guns, although had no experience in making guns for the War Office. Coventry had produced both field guns and howitzers, but their experience in guns over 6-inches was limited, even if their plant could handle much larger weapons.

Woolwich and the Royal Gun Factory could build up to at least the 13.5-inch gun which they had received an order for in 1913. The Royal Gun Factory could also rebuild everything in the arsenal back to new condition, as well as house the inspectors and deployment to bases



anywhere on the globe. The total output of the industry had probably never exceeded 200 to 250 guns a year, of which 75 per cent would have been small guns, and only from 1905–1908 at that. The overall tonnage, and certainly the average weight per gun had steadily increased, thanks to the post-*Dreadnought* capital ships being ordered by the Admiralty, although it was far from certain that this capacity would be able to mobilize. Britain did though have a developed stable of mature designs at all ballistic levels. The question would be what the industry, if called upon, could dust off these plans and fit out a British force in a reasonable time.

### **Requirements of Empire**

Britain's Empire was by the second decade of the 20<sup>th</sup> century the largest the world had ever seen. Although this required a flexibly armed navy, the army was the primary customer when it came to efficient ordnance. India was by far the largest customer of the overseas territories, although Canada, Australia, and New Zealand also purchased and outfitted their forces on the model of British forces. India's needs however were great enough to affect the design of ordnance that would equip the European forces. India always had a representative on the Ordnance Board, although in reality the representative traditionally reserved comment to exclusively Indian topics.

The driving design factor from the perspective of India was weight. The bridges on the subcontinent were not built to the same strengths as those in Europe and campaigning with heavy artillery pieces, especially in the northern regions of the Raj, was out of the question. The British in India did not acquire the 60-pr in 1905 when the British Army did, for this very reason, and continued using the older guns because of the weight difference. The Government of India wanted to replace their aging 4-inch BL Gun, 30-pr BL Gun, and 5-inch BL Gun with a new siege gun. All of these, even in India were obsolete. British requirements were for an absolute weight that could not exceed 84 cwt under horse traction. The desire was to have a range of 10,000 yards, due to many international events, mainly the Russo-Japanese war, the retiring of heavy guns by every world power save the USA, and, unsaid, the experiences in South Africa. Interestingly, India admitted it was difficult with current technology to control any round over 8,000 yards.<sup>234</sup> This showed a disconnect between the requirements and realities. India used Royal Artillery gunners, so designers in London would have also been aware of this although it is never mentioned for the 60-pr design project, and its 10,000 yard range. India's feelings about range were minimized by the invention of spotter

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<sup>234</sup> SUPP 6/544. Extracts from proceedings Royal Artillery Committee. 15-16.

planes in the second decade of the century. Nonetheless, the requirements of India did affect what was accepted for the force as a whole.

On the other hand, Canada and the other colonies utilized standard British field artillery, and the defences of the ports were given to the Royal Garrison Artillery. The Royal Garrison Artillery operated the same specification worldwide and there was little interaction with the local authorities. Garrison guns appear infrequently in the Ordnance Board meeting notes. This probably had more to do with their longer lives due to training requirements as much as anything else.

### Obsession with Shrapnel

Britain was obsessed with shrapnel. The primary reason was that the high explosive shell that was currently in service used Lyddite, an explosive made from picric acid. Unfortunately, Lyddite had gained the poor reputation in South Africa of detonating prematurely, which put the services against it.<sup>235</sup>

A top-down review of shrapnel was conducted in 1902 to ascertain what increases in efficiency could be gained by introducing higher quality shell steel. Better steel allowed for more shrapnel projectiles to be in the

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<sup>235</sup> Hew Strachan. *The First World War: Volume I: To Arms*. Oxford: Oxford University Press, 2003. 1000.

casing as the new steel allowed thinner walls. This would have detrimental effects in 1914 and was probably a direct cause of the shells crisis, when the quality of shell steel would not be available to the country in amounts needed.<sup>236</sup> This is a topic that, although outside the purview of this study, needs to have an analysis conducted in the wider historiography.

### **Steel Production in Britain**

It is difficult to state definitively what processes were being used to make steel from all suppliers of ordnance in the period in question. The primary concern was that the processes were considered trade secrets, and furthermore, the Government in general did not care or specify processes. This was for several reasons, first being they wanted to keep a wide array of suppliers available to keep prices low, and second, to reinforce that as long as tests for steel passed inspection both physically and chemically, they preferred to not interfere. The President of the Ordnance Committee went so far as to write in 1905 that ‘There is, moreover, a general consensus of the opinion that for the present it is desirable to leave Manufacturers a considerable latitude in this respect, and, as the subject must be regarded

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<sup>236</sup> SUPP 6/61. Annual reports of the president. 1902. 47.

as being more or less in an experimental stage, the Committee are of the opinion that no hard-and-fast Specification should be laid down.’<sup>237</sup>

As new steels came onto the market at the turn of the century, the Government also became interested in potential uses. Part of the problem with any transition to new steels might have been the process itself for making steel. Controlling the chemical composition of steel was much more important in ordnance steel than probably any other use by the turn of the century. By 1902 many suppliers of castings were providing steel made from the Tropena process, which was similar to the Bessemer, and had largely replaced the previous method of open hearth steel. The Tropena process produced less carbon, although for ordnance use manufacturers had a problem with creating blow holes. Even with this, the Royal Laboratories started using Tropena process as well, as they were achieving better quality in small and large castings of shells with the new process compared to open hearth. The process also allowed apparently faster production.<sup>238</sup> Tropena steel was used by Vickers as well as Edgar Allen & Co of Sheffield by June 1902. As it had been used by the Royal Arsenal since 1896, it was decided not to ban or change any policies with this process.<sup>239</sup>

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<sup>237</sup> SUPP 6/65. Annual reports of the president. 1905. 135.

<sup>238</sup> SUPP 6/61. Annual reports of the president. 1902. 95-96.

<sup>239</sup> SUPP 6/61. Annual reports of the president. 1902. Appendix 88-89.

By 1909, the process of making steel for guns had changed. Most steel for gun manufacture came then from open hearth methods, with crucible steel still being in use as well. This might have been the direct effect of having to make more alloy steel. Electrical furnaces were still not in prevalent use, although the Inspector of Steel did believe that the electrical furnace was more likely to displace the crucible than the open hearth furnace.<sup>240</sup> This was the last reference before the war on steel making in annual reports.

The Admiralty went as far as to declare the Bessemer process as ‘not at present considered being suitable for manufacture of gun steel’, this leaving the Siemens Open-Hearth technique as the only viable manufacturing technique for gun making by 1914.<sup>241</sup>

## **Experiments**

Experimentation was a mainstay of ordnance manufacture and improvement in the period between 1900 and 1914. Experiments took many forms, from rifling, to cordite, to metallurgical tests. The overarching goals were to make guns safer, last longer, be more powerful, and hit the target more often. Many experiments on the surface do not seem to have

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<sup>240</sup> SUPP 6/164. Annual report of the president. 1909. 62.

<sup>241</sup> ADM 186/220. Manual of Gunnery for HM Fleet. 37

much relevance, although put together over the long term, the contribution of those conducted at Aldershot, Shoeburyness, and Woolwich was sizeable.

Many experimental reports look just like the one that follows: for some reason, lubricated shells were achieving lower velocities and no sizeable difference in accuracy from non-lubricated rounds when testing 7.5-inch rounds. Any increase in accuracy seemed to be from the lube creating drag and slowed projectiles down and thus saved the driving bands, whereas the unlubed ones had smooth driving bands.<sup>242</sup> This appeared counterintuitive to the rational thought before experimentation. When experiments mention smooth drive bands, this meant the projectile had imparted too much energy on the soft bands of the shell. This in turn caused the projectile, now without a surface to engage the rifling with, to spin in the barrel. In turn the final result was the lands of the rifling sheared off all the copper from the driving band. This was usually a tell-tale sign from the expended shell of inefficient shell ballistics, increased barrel wear, and shortened and erratic flight. This experiment showed that harder materials for this particular drive band were needed, which helped lead to more stable and harder hitting rounds.

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<sup>242</sup> SUPP 6/65. Annual reports of the president. 1905. 59.

Powder and propellant were also extensively experimented with. In this case, there was a difference in erosion with nitroglycerine powders used by 'foreign' powers, as they were more corrosive and eroded faster, and therefore, cordite was used because it made barrels last longer.<sup>243</sup> This though was initially more of a thought experiment, as not enough foreign powder could be had, although these tests were extensively tried in 1915 and later through the use of American-made powder as the wartime requirement made foreign procurement a necessity.

Experiments also were conducted to evaluate foreign ideas. For instance, Bofors of Sweden in 1907 offered to sell a 9.45-inch gun to the Admiralty made of cast steel, instead of forged steel. The Chief Superintendent Ordnance Factories questioned the possibility of such a gun without imperfections, but also questioned why the price was so high as it seemed that the lack of forging should have made it much cheaper. Chief Superintendent Ordnance Factories surmised it was either due to massive profits, or very expensive heat treatments. What was obvious was that Bofors had much greater skill in casting and handling than was available in the UK.<sup>244</sup> The Chief Superintendent's theories were products of experience in casting and forging at the Royal Gun Factory and Royal Carriage Department. Information also came from internal British supplier

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<sup>243</sup> Ibid. 123.

<sup>244</sup> SUPP 6/163. Annual report of the president. 1908. 26.



sources. Hadfield's proposed a steel that was similar to the Bofors of Sweden product. Hadfield's first proposed a concept in the UK for cast steel guns. The US also used cast steel, but only for guns up to about 6-inch, apparently with good results. Further requests to Bofors, though, showed what was believed to be an inferior gun of 9.2-inch size, and of the same cost as current service British guns.<sup>245</sup> This knowledge of how to evaluate proposals could only come from staff who had extensive experience in materials, but also knew how they fail when the right conditions do not occur.

### **Other Experimental issues**

The experiments staff sometimes came up with curious ways to continue experiments in ways that would be considered unsuitable for field use. By 1905 the 1880s era 13.5-inch Mk I guns used in proof and evaluation were completely worn out, and the Inspector at Woolwich was trying to get more life out of them by increasing the driving rings with a larger expansion of soft metal 1.5 inches wide and .10 inches thick. This was required to keep the projectile from falling out of the barrel during

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<sup>245</sup> SUPP 6/67. Annual reports of the president. 1907. 30.

ramming.<sup>246</sup> This appears to have given a bit more life to a gun that was obsolete, but useful in studying questions pertaining to large projectiles.

Experiments also helped prove scientific principles. The formula used to predict projectile weight was determined by a calculation created in 1883 as  $W/d^3$  of approximately 0.5. As well, projectiles were not to be in excess of four calibres in length. With these two calculations, a basic maximum weight of projectiles was created. In general, the lighter projectile had a flatter trajectory, and a heavier projectile had more striking power. As well, ‘assuming the charge to be the same, the heavier projectile possesses the following advantages:– 1 Somewhat more energy is obtained from the charge, 2 Owing to the lower velocity the resistance of the air is considerably reduced, and 3 the heavier shot has greater capacity for overcoming the reduced resistance.’<sup>247</sup> These principles were used to shape the experiments for new guns, especially the 13-pr and 18-pr project.

What might have been the most probing of experiments was the study of rifling. Experiments in 1908–1909 showed the non-driving edge received different heat effects, causing possible spot annealing and other problems that were believed to cause cracking and other effects.<sup>248</sup> In addition, experiments proved standard constant pitch rifling seemed to

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<sup>246</sup> SUPP 6/65. Annual reports of the president. 1905. 1–2.

<sup>247</sup> SUPP 6/60. Annual reports of the president. 1901. 63–64.

<sup>248</sup> SUPP 6/164. Annual report of the president. 1909. 52.

create an oscillation of the projectile in high velocity guns, whilst progressive rifling appeared to create exceedingly heavy strain on the driving band in the later stage of transit through the barrel.<sup>249</sup> At the end of every year a report on the rifling experiments and the results were published in the President of the Ordnance Committee's report, although, with a secret clearance and 25 copies at best, this was to say the least not common knowledge.

### **Failing Guns**

During the 1904 annual exercises, HMS *Majestic*, a Pre-Dreadnought built in 1895, cracked all four of her 12-inch, Mark VIII guns. This was the most drastic failure in a string of cases that had been occurring since at least 1902. The main gun outfitting British battleships was failing. In three years from 1902 through 1904, 20 primary guns had failed, mainly due to the carbon inner tubes failing. Before this, three brand new 12-inch Mark IX guns had failed, one from HMS *Exmouth* in July, and at Shoeburyness in September and October, all made by Vickers. In addition, a 12-inch Mark V failed in March at Woolwich, a 9.2-inch Mark X in January 1903 at Warden Point, Isle of Sheppey, Kent, from Vickers, and another 9.2-inch Mark X, at the Woolwich proof butts in

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<sup>249</sup> SUPP 6/63. Annual reports of the president. 1904. 96.

May 1904 from Elswick. Finally in May 1904 a 9.2-inch Mark V from the Royal Gun Factory burst on HMS *Galatea* along with one made at Elswick which only cracked. Shoeburyness had 6-in Mark VIIIs fail in November 1902, December 1902, three in May 1903, and a 5.8-inch test gun in November 1902.<sup>250</sup> These failures represented a failure of British guns of all types and sizes and for both the Royal Navy and the Royal Garrison Artillery.

The sulphur content seemed to be even more important for large guns than other classes. The metal from failed 12-inch VIII, No 66 was sent from the National Physical Laboratory to the major gunmakers, as well as Firth and Brown. Brown noted that the sulphur content was almost 50 per cent higher than what they thought acceptable, .05 versus .035, and that this would alone have probably caused the failure.<sup>251</sup> The seemingly small differences in trace materials showed just how fast and far specialty ordnance steelmaking was moving.

### **Guns Failing Due to Misuse**

Two guns were involved in accidents in 1902. A 12-inch Mark VIII gun from HMS *Mars* and a 6-inch from HMS *Royal Sovereign* both

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<sup>250</sup> Ibid. 102-103.

<sup>251</sup> SUPP 6/163. Annual report of the president. 1908. 17.

received failures due to errors by of their gun crews. As well, a failure of a 15-pr gun had a complete burst in South Africa caused by it being double loaded.<sup>252</sup>

The *Mars* incident was caused by the breech not being fully closed, so human error. This type of gun was equipped with an electrical firing mechanism and although the main electrical circuit normally stopped this type of misfiring, it was bypassed to an auxiliary and upon inspection no threads of the breech block were engaged, meaning essentially that when the charge was ignited, nothing was behind it to stop the breech from exploding into the turret.<sup>253</sup>

### Cast Steel Experiments

As it would take a considerable time for a new 12-inch gun to wear out under service rates, the ordnance committee proposed taking an old 13.5-inch gun and relining it to the 12-inch specification for the sake of firing until worn through proof and evaluation purposes. It would allow for a controlled environment that could also allow for testing of material under laboratory conditions afterwards. The committee ignored Vickers chromium steel and used the Elswick experimental nickel steel.<sup>254</sup>

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<sup>252</sup> SUPP 6/61. Annual reports of the president. 1902. 90-91.

<sup>253</sup> Ibid. 93.

<sup>254</sup> SUPP 6/66. Annual reports of the president. 1906 122-123.

Hadfields had spent considerable resources on a new steel in 1905 and 1906 that was to show apparently the properties of Specification #22 steel, yet could be cast as well as forged. They had little apparent success in delivering a forging large and pure enough to make a 7.5-inch liner at the Royal Gun Factory out of it. This might have been the basis for a new type of steel Hadfields had been working on called Era steel. Era steel was also not accepted for castings, although it does appear to have been used for breech mechanisms and other small parts.

Tests conducted on Hadfield experimental barrels showed that slight imperfections in metallurgy were not as important in shortening the life of the barrel as were slight imperfections in the casting of the steel itself.<sup>255</sup>

## **Conclusion**

Gun design evolved greatly between 1900 and 1914. The underlying 'Britishness' of the designs though played greatly into how guns evolved. Failures early in the time period had a significant effect on the experiment and design in the last decade leading to 1914. Importantly though failures and limitations of British industry led to experiments in steel which will be explored in more detail in the next chapter.

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<sup>255</sup> Ibid. 138.

## CHAPTER SIX: EVOLUTIONS IN STEEL AND VICKERS FAILURES

### Introduction

After the failure of the guns from HMS *Majestic*, The British government spent several years improving the steel used for the inner jacking of guns. In a short time, British gun metallurgy increased exponentially. This chapter discusses how this happened.

### Nickel Steel

‘Nickel by itself, or when used with *Chromium*, increases the tenacity of the steel without appreciably reducing the ductility.’ And ‘Nickel and nickel-chrome steels appear to possess greater resistance to shock than carbon steels’<sup>256</sup> The first test of this new alloy was conducted with a nickel steel inner ‘A’ tube ordered for a scheduled relining on a 6-in Mark VII gun as way of testing the erosion and other properties of using such metal such as rust and erosion. The gun was then to be sent for test, proof, & evaluation work, as many more rounds could be quickly and accurately fired in this environment than onboard a working ship.<sup>257</sup> Importantly, the

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<sup>256</sup> ADM 186/220. Manual of Gunnery for HM Fleet. 30, 31.

<sup>257</sup> SUPP 6/60. Annual reports of the president. 1901. 4.

head to head test between the service carbon steel and new nickel steel was inconclusive.

### Initial Nickel Steel Tests

The Ordnance Committee though wanted to continue tests, which would continue with the Experiments Committee.<sup>258</sup> The experiments showed that the gun made of nickel steel had actually worn more aggressively than the carbon steel bore at 50 shots, and the experiment was discontinued.<sup>259</sup> This initial test, although superficially inconclusive, was important in gathering basic information on how nickel steel reacted against the service designs as well as collecting data on the strengths and weaknesses of the material in a well-researched and well documented platform of the 6-inch Mark VII. In addition, the unexpected results led the Ordnance Committee to conduct a conference with steel manufacturers as to what their thoughts were on utilizing the material, as well as a canvassing of the industry to see who could and would produce the new nickel steel if an order was issued.<sup>260</sup>

In October 1902 the Committee asked manufacturers what their thoughts were for nickel steel and its productivity.<sup>261</sup> Although the notes of

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<sup>258</sup> SUPP 6/61. Annual reports of the president. 1902. 10-11.

<sup>259</sup> Ibid. 60.

<sup>260</sup> Ibid. 62.

<sup>261</sup> Ibid. Appendix 62.



that October 1902 conference do not survive, the Ordnance Committee must have been inspired, as the next new gun to be ordered designed was required to be made exclusively out of nickel steel. (The gun wire was excepted).<sup>262</sup> This new 7.5-inch gun was to incorporate the experiences of the 6-inch whilst also furthering the study. It was almost unheard of, though, that a new weapon design for an operational need was ordered without a steel specification and laid down with unproven technology. No mark designation was given in the Committee report, although from the time frame, this was likely the 7.5-inch Mark II, which was designed as a garrison artillery piece.

At the same time, more experimental tubes were ordered from Sheffield based Thomas Firth & Sons in 1904.<sup>263</sup> The contract was for a 6-inch Mark VII inner 'A' tube at a cost of £162/2/0.<sup>264</sup> The company had a proven record for experimental steels as well as being a primary supplier of finished tubes to the Royal Gun Factory and the firm was given a free hand to create a nickel steel that they believed would be best for large gun construction.

Cammell Laird appears to have been the first large-scale manufacturer to really engage the Committee on the possibilities and

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<sup>262</sup> SUPP 6/62. Annual reports of the president. 1903. 21.

<sup>263</sup> SUPP 6/63. Annual reports of the president. 1904. 26.

<sup>264</sup> WO 395/2. Annual Reports 1903–1908. 49.

constraints of nickel in steel. They wrote to the Ordnance Committee on 25 February 1904 stating that Britain was well behind the curve and much more had to be done quickly to stop a perceived technology gap. They stated some basic discoveries in their metallurgical research, but admitted that testing was needed as much as anything to ascertain the true effects.<sup>265</sup> In addition, in 1905 reserve guns of the 12-inch Marks VIII and IX type had been allowed to be made by Elswick and Vickers to put in nickel sleeves of their own designs<sup>266</sup>

The second gun that would incorporate nickel would arrive in 1904. The 9.2-inch Mark XI gun was to be the last 9.2-inch gun designed and accepted for British service. 9.2-inch guns were the main armament for many coastal batteries through the Empire as well as being secondary armament on pre-*Dreadnought* battleships and primary armament on many smaller vessels. Although drawings were originally created by Armstrongs to utilize standard carbon steel in 1903, by the next year the physical examples were being built from nickel.<sup>267</sup> This was the first time a gun had been retrofitted for front-line service to updated steel specifications in mid-construction.

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<sup>265</sup> SUPP 6/64. Annual reports of the president. Note: Appendix 1904. 174-175.

<sup>266</sup> SUPP 6/65. Annual reports of the president. 1905. 5-6.

<sup>267</sup> SUPP 6/63. Annual reports of the president. 1904. 25.

## The First Production Orders

The largest order though for nickel steel by number of guns was almost not to be. On 12 January 1904 the Ordnance Committee formally suggested that the 'A' tubes of the army's new 13 and 18-pr field guns would be made out of nickel steel, although, with this being such a large order, (as discussed in Chapter Four) it was dependent upon the industry being able to produce them.<sup>268</sup> In the end, the final procurement would be split due to that industrial issue. By the 23<sup>rd</sup> of May 1906, 353 nickel variants and 240 carbon variants had been delivered. Not a single nickel gun had been delivered by Vickers. Coventry Ordnance Works and Elswick had exclusively delivered nickel guns, and the Royal Gun Factory had produced 26 nickel and 142 carbon guns.<sup>269</sup> The order, which would produce well over 500 field guns, did not appear to prejudice one gun over another, and the guns of different manufacturers were dispatched to the same batteries with no distinction between the barrels.<sup>270</sup> It was unlikely that the end users even knew the difference between gun steels. Although the Ordnance Committee pointed out that a nickel steel barrelled Elswick built 12.5-pound gun of the Royal Horse Artillery had, after 1,654 rounds, only

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<sup>268</sup> SUPP 6/543. Report of the Special Committee on Horse and Field Artillery Equipments. Final Report, 1904. 8.

<sup>269</sup> SUPP 6/66. Annual reports of the president. 1906. 53.

<sup>270</sup> Ibid. 47.

.032 in rifling wear, and no increasing in scoring.<sup>271</sup> This really was an incredible feat, for the material that just four years earlier had almost been written off by inconclusive results. Vickers' inability to deliver nickel guns that would consistently pass inspection would continue for another six years, and it is this point that has been completely void in all secondary sources.

### **Initial Vickers Issues**

‘At a meeting which was called for the purpose of considering the introduction of nickel steel into gun construction, they (Vickers) at that time thought that a minimum breaking stress of 45 tons could be obtained, but, as they pointed out at the meeting, their experience of nickel steel to this analysis in large masses was not very great, and it was not until they got into the general manufacture of this steel that they found that a modification in the minimum breaking stress would be desirable in order that delays should not occur in the manufacture of heavy forgings entailing the use of especially big ingots’<sup>272</sup> Vickers could only guarantee 30 tons elongation, when 45 was the specification that Armstrongs was able to produce. In addition Report 1183 from 5 December 1905 stated that the

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<sup>271</sup> SUPP 6/63. Annual reports of the president. 1904. 82.

<sup>272</sup> SUPP 6/65. Annual reports of the president. 1905. 30.

carbon content in nickel steel should not exceed .4 per cent.<sup>273</sup> This report, combined with the elongation issues, gave Vickers a double difficulty in producing on contract, an issue that will be discussed later.

### Naval Issues with Nickel Steel

Starting in late 1904 through 1907 the Director of Naval Ordnance, then Capt. (later Admiral of the Fleet) John Jellicoe worked to inject new materials into naval gunmaking. This was in direct response to the 12-inch Mark VIII gun failures on *Majestic* and others that put him in a difficult position with most of his guns compromised, with old guns that cracked and newer guns that wore out faster. Jellicoe saw that nickel steel could be the answer to both of these problems. Many new experiments were run, primarily by the Chief Superintendent of Ordnance Factories and the Chief Inspector, Woolwich, in cooperation with the Inspector of Steel, Sheffield. The result was that by 1905 nickel steel had entered in direct competition against the old ordinary or carbon steel that had been used for the last 20 plus years on naval guns. This transition was so successful that by 1908 most guns made for the Admiralty were made of nickel steel, and by 1910 all guns were being made to the nickel steel specification.

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<sup>273</sup> SUPP 6/66. Annual reports of the president. 1906. 122.

Some clarification should be noted. Only the inner ‘A’ tube was made of nickel steel, and the wire specification did not change. The outer jacket that covered the wire and added to lateral rigidity as well as protection for the lower levels could be made in carbon or nickel steel.

On 28 September 1905 the Director of Naval Ordnance noted that the difference between nickel and carbon inner and outer ‘A’ forgings on 12-inch Mark X was £14,440 difference over 30 guns ordered. £481 per gun was considered worth it to the committee.<sup>274</sup>

### **Industrial Dialogue**

Another meeting with the steel industry met in June 1905. It came out in this meeting that manufacturers were still having a difficult time at making nickel forgings, but also that there was some inconsistency in manipulating the manufacturing process for alloy steel.<sup>275</sup> Although it is not known which parties overall had what comments, it is doubtful that Cammell, Coventry, or Armstrongs were complaining. The overarching takeaway from industrial comments for nickel steel specifications was that all manufacturers were willing to comply with what the Committee and Inspector of Steel decided, but they wanted a return loop to learn from

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<sup>274</sup> Ibid. 141.

<sup>275</sup> SUPP 6/65. Annual reports of the president. 1905. 4.

their acceptances and mistakes. Overall, it seems that the steel industry in the UK wanted to strive for process improvement.<sup>276</sup>

The nickel transition was probably easiest for Armstrongs who had an extensive metallurgical department and a more scientific approach to building ordnance. It was essentially Armstrong's specification that became after much trial the government specification, S/22. Armstrongs also had a relatively low rejection rate of forgings after the initial learning period. On the other hand, the conversion to alloy gun steels almost brought Vickers to their knees. It was mentioned earlier that they could not produce a single field gun to the nickel specification, and the Government's inspectors believed this was due to Vickers not having clean enough crucibles which therefore left trace elements in their batches. These trace dissolved oxides, in the form of alumina, then required aluminum to allow slagging of the unwanted elements.<sup>277</sup> Unfortunately for Vickers, the use of aluminum in all stages of manufacture was strictly forbidden within the steel specifications for British ordnance.<sup>278</sup>

Four years later, Vickers could still not produce a consistent nickel steel tube for large guns. They tried to use instead a nickel-chromium steel that was inadequate to compete with nickel in British designs and powder,

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<sup>276</sup> Ibid. 137-140.

<sup>277</sup> ADM 186/220. Manual of Gunnery for HM Fleet. 31.

<sup>278</sup> SUPP 6/63. Annual reports of the president. 1904. 82.

and they remained with this alloy until it was banned by the Ordnance Board for being too flawed too much of the time. Before then though, the Superintendent, Royal Gun Factory stated that he did not believe that a chromium forging by 1904 could be found that could comply with the specification, but nickel steel could comply with new specifications for elasticity and other specifications.<sup>279</sup>

It was not until 1912 that Vickers had figured out both the process of forging nickel steel and annealing it consistently enough to pass the Inspector of Steel inspections on a consistent basis. This lack of understanding in the material greatly affected some designs, especially the 12-inch Mark XI gun that was dropped after just six ships.

### S/22 Emerges

The eventual outcome of the large amount of experimentation was that the Chief Inspector Woolwich forwarded on 20 December 1905 Specification S/22 of nickel steel for ordnance to Inspector of Steel. This was even after a 5 December 1905 report that showed Vickers had yet to successfully cast a single lot of the proposed specification and were still obsessed with trying to mimic Krupp chromium steel.<sup>280</sup> S/22 was intended to replace S/20 which was of nickel steel for field guns and used in the 18-

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<sup>279</sup> SUPP 6/65. Annual reports of the president. 1905. 12.

<sup>280</sup> SUPP 6/66. Annual reports of the president. 1906. 122.



pr project. The original S/20 had 3 per cent nickel, although research had shown that 6 per cent was much more desirable for larger forgings, which the new specification utilized. It was provisionally approved by the Committee after provisional acceptance in February 1906 based on chemical tests as well as Director of Naval Ordnance suggestions on chemical composition.<sup>281</sup> The fourth publication of S/22 was released on 10 May 1907, which removed provisional status, thus bringing Specification S/22 into full effect, as well as requiring ‘contractors’ to mark where their steel came from, if it was not produced in-house.<sup>282</sup> This was to allow more oversight from inspectors, as sub-contractors had become more important in the supply chain, such as Firth, Cammell, and Darlington.

The final specification for the S/22 steel was a compromise between the elasticities that were capable of being produced by the British steelmakers. The committee eventually set down a specification for performance, with 30 tons minimum elastic point, not less than 16 per cent elongation, and a minimum 45 tons and max 55 tons breaking stress.<sup>283</sup>

Even then, the experimental stage was not over. The Inspector of Steel noted in a letter dated 28 August 1906 that ‘It is somewhat curious that Elswick, presumably to avoid cracks, are beginning to use chrome in

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<sup>281</sup> Ibid. 119–120.

<sup>282</sup> SUPP 6/67. Annual reports of the president. 1907. 50.

<sup>283</sup> SUPP 6/65. Annual reports of the president. 1905. 136.

12-inch, 'A' tubes with less carbon, while Vickers, possibly to avoid chinks, are raising carbon and abolishing chrome, and Openshaw go on comfortably, hitting off about the middle of the Specification without either chrome, chinks, or cracks.<sup>284</sup>

### **Later Nickel Steel tests**

The 1907 Hadfield comparison tests were cancelled halfway through as being inconclusive to finding the best new steel composition.<sup>285</sup> It was not apparent that any of these tests were published to steel makers, including Hadfield's. Another test was conducted in 1908 on excess parts of forgings that were already worked. The results were sent to the six principal steel and gun makers: Messrs. Firth, Coventry Ordnance Works, Armstrongs, Hadfield, and another unresponsive source, probably Vickers.<sup>286</sup>

Tests continued well after the setting of the S/22 specification, with a 1908 test with a 6-inch Mark VII gun after 862 rounds demonstrating that the nickel steel was 'distinctly tougher than the carbon steel tubes similarly tried' This was the conclusion of the tests for No 2,002.<sup>287</sup>

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<sup>284</sup> SUPP 6/66. Annual reports of the president. 1906. 143.

<sup>285</sup> SUPP 6/163. Annual report of the president. 1908. 43.

<sup>286</sup> Ibid. 44-45.

<sup>287</sup> Ibid. 20.

In the end though, even after all of the Research and Design that was conducted, intelligence reported that American nickel steel seemed to be better.<sup>288</sup> Nonetheless, it would be the specification set forth in 1906 that would be the main steel in British gun barrels by 1914.

### Chromium Steel

There was another option used internationally that could challenge nickel steel: chromium steel. In Britain though chromium was found to be exceedingly difficult to work in large forgings, and therefore was considered not necessary for large casting orders. The 12-inch gun orders mentioned above made with S/22 steel were to be made of 6 per cent nickel, instead of the 3 per cent used for field pieces because it yielded better results in large guns and was easier to work with.<sup>289</sup> Of course, Vickers disagreed and thought that they could add chromium into the mix.

From a report of the Superintendent of Research, it was believed that nickel steels took heat treatment differently from chromium steels. The difference appeared at the time to be that nickel steel was much more elastic, whereas chromium steel acted in a similar way to carbon steel.<sup>290</sup>

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<sup>288</sup> SUPP 6/65. Annual reports of the president. 1905. 189.

<sup>289</sup> Ibid. 13-14.

<sup>290</sup> SUPP 6/163. Annual report of the president. 1908. 42.

Vickers though believed that there was more to chromium steel than was apparent to their British competition. It seems that their mind-set was based upon the business plan that Krupp steel was chromium steel. It is not discussed in the technical reports as to why Vickers thought that this was better, although it might have something to do with the export market. It could be surmised that Vickers thought that employing a chromium steel would give a competitive advantage in winning lucrative foreign contracts in places such as Brazil, Argentina, and the Ottoman Empire. This would be about the only plausible reason why it was not mentioned in official reports, as the Government had a hands off approach to foreign deals as long as they did not affect the supremacy of British forces.

In the end, chromium steel died a relatively quiet death. On 20 February 1907, the drawings and designs for all liners of modern guns officially incorporated nickel steel as the material of choice in relining guns.<sup>291</sup>

Although chromium was off the table for production guns, experiments were still wanted. An order for two 12-inch liners for the old 13.5-inch guns used for proof and evaluation in June 1907 found that nobody was actively producing the material, which gave Armstrongs the

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<sup>291</sup> SUPP 6/67. Annual reports of the president. 1907. 20.

opportunity to submit a very large bid, which caused the solicitation to be revoked.<sup>292</sup>

The records do not say when and why Vickers gave up on their precious chromium steel project. It is still not understood why Vickers had such trouble and still kept with it. The other manufacturers did not even bother except under experimentation purposes. Consistency in the new steel could not be produced by Vickers, and their annealing furnace and process was not able to rectify many of the problems. After the continued rejections of Vickers guns, the Chief Superintendent of Ordnance Factories backed by the Director of the National Physical Laboratory recommended to the Ordnance Board in 1909, who agreed that the specification for nickel chrome steel be suspended. This was only for future work, and was grandfathered in for work that was under contract currently.<sup>293</sup> After 1908 not a single chromium forging was used to build up guns in the Royal Gun Factory, and significantly for Vickers market share, Vickers had not provided a single forging of any type between 1908 and at least through 1910 to the Royal Gun Factory.<sup>294</sup> The Inspector of Steel never mentioned the inspection of the material again. Vickers had transferred to nickel steel, although much capital outlay and work in plant

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<sup>292</sup> Ibid. 1.

<sup>293</sup> SUPP 6/164. Annual report of the president. 1909. 13.

<sup>294</sup> SUPP 6/165. Annual report of the president. 1910. 67.

and process were required before their work was consistently passing inspection.

### Tungsten Steel

It must be noted that nickel steel was not universally believed to be a proper material for gun making. In the wider commercial steel community there was a belief as late as 1903 that nickel steel could ‘convert the fibrous structure of the treated tube into a crystalline one, thus also increasing erosion’.<sup>295</sup> Therefore, that heat affected the microscopic properties of steel was a serious belief. In 1909 tests on tungsten steel showed it to be inferior to both nickel and carbon steel in erosion tests.<sup>296</sup> It was also proposed in 1910 to look into nickel-tungsten steel for guns, but the Ordnance Board, influenced no doubt by a secret 1909 test, axed this due to the extreme rarity of tungsten available. They also stated that for some reason the alloy steels were less able to take the heat of cordite, due to their lower melting points. The German Erhardt guns made out of the tungsten steel might have been, according to intelligence, better suited due to a cooler propellant. This was an unverified argument that the Board did not consider it worth looking into.<sup>297</sup>

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<sup>295</sup> SUPP 6/63. Annual reports of the president. 1904. 26.

<sup>296</sup> SUPP 6/164. Annual report of the president. 1909. 45.

<sup>297</sup> SUPP 6/165. Annual report of the president. 1910. 70-71.

## Vickers Failures

Vickers had a string of failures stretching from 1903 through at least 1912 that has been completely missed by historians to this date. The sheer scale of this failure is arguably the single largest failure of the British Ordnance industry since the Crimean War and put great strain on the resiliency of the industry. Importantly, this does not appear at all from corporate records, which is why it has probably been undiscovered by historians.

Several Vickers guns were failing inspection in 1903 due to poor workmanship and careless mistakes in rifling: at least one 9.2-inch gun and possibly a 12-inch gun were rejected due to shoddy work.<sup>298</sup> A 7.5-inch gun cracked so badly that it was written off when the liner was not even fitted before submission.<sup>299</sup> This was just the first of a long string of issues with the firm.

A 7.5-inch gun made in 1905 by Vickers was produced that intentionally hid and deceived the Government about its flaws. The rear of the inner 'A' was made to 19.1 inches instead of its specification of 19.8 inches. This was not discovered until the gun went to proof. Vickers was allowed to fix the problem somewhat, but it appears that the problem

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<sup>298</sup> SUPP 6/62. Annual reports of the president. 1903. 15.

<sup>299</sup> SUPP 6/62. Annual reports of the president. 1903. 18.

occurred when the Government resident inspector was not on-site when the gun was being made, and thus Vickers thought they could get away with it.<sup>300</sup> This was not an individual incident. Vickers was known by inspectors for not always passing off goods as they were promised. This was due to a variety of factors that will be discussed in this section.

It was with this attitude that puts into context when Vickers would challenge governmental specifications. In one instance, according to a 20 April 1905 letter Vickers still believed that a steel of 28 tons elastic limit would do fine for 9.2-inch high velocity guns, completely negating both Armstrongs and the Royal Gun Factory.<sup>301</sup> This might be in some part why Vickers-made 12-inch Mark IX guns were plagued by cracking. Four of their guns were cracked within the first 50 rounds, and they had great problems in getting guns approved. Two of these guns were rejected and relined and still cracked, one on round 30.<sup>302</sup>

The failure of the Vickers designed 12-inch Mark IX gave the Ordnance Committee an opportunity to take a new approach to the next big gun for the Royal Navy. The design for the 12-inch Mark X, 45 calibre gun came from the lessons of Vickers failing with both the 12-inch Mark VIII (designed by Woolwich) and IX (designed by Vickers). The new

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<sup>300</sup> SUPP 6/66. Annual reports of the president. 1906. 24.

<sup>301</sup> SUPP 6/65. Annual reports of the president. 1905. 35.

<sup>302</sup> Ibid. 15-17.



design was based on strengthened shoulders, the new use of nickel steel, the understanding of new pressures with cordite, and the understanding of the effects of ballistics on the partial or full wiring of the barrels. It was truly the first fully modern gun designed in Britain. It was in reality a Woolwich design that was suggested for improvement by Vickers, although the credit is often given to Vickers for the design. The 12-inch was also in all likelihood the basis for all guns in the next decade, just as the 6-inch Mark VII had been the basis for all ballistics for the period before this. This gun design also caused the Government to have both the contemporary 9.2-inch and 7.5-inch gun designs sent back to Vickers to be redone.<sup>303</sup> This does not seem at all like a positive experience for Vickers, as they basically were told all their earlier designs for big guns over 6 inches were not good enough, essentially enforcing a latent defect clause in today's parlance.

### **Governmental Interventions**

To add insult to injury, the Director of Artillery was so impressed with Armstrongs guns (or unimpressed with Vickers) by late 1905 that they were willing, with Armstrongs permission, to send work done by Armstrongs to Vickers to let them see how to build nickel guns. This was

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<sup>303</sup> Ibid. 25-26

not a vote of confidence in Vickers and was also a huge boon for Armstrongs steel quality.<sup>304</sup>

It is also a fascinating insight into how the British Government worked with their industrial partners that could not deliver. The board wanted to point out in the annual report of 1908 that Elswick submitted nickel forgings of quality well in excess of Vickers. The Inspector of Steel on 7 July 1908 was puzzled as to how Vickers was unable to produce quality products. Vickers had installed a new annealing furnace in 1907, but was astonished when it did not work. The company then rebuilt the furnace and installed forging rotators that kept the billet moving while annealing, and apparently this produced better results. That being said, it was not only with annealing that there were issues. 120 of 640 test pieces were streaked green, and 90 percent had laminated fractures. Therefore, casting was defective, as the rejections were three times more likely at the breech than the muzzle end.<sup>305</sup>

At times, chemical differences and inconstancies were noted between the inspections from the Chemist War Department, and those by the manufacturers. Although this became less common, the science of the day did not allow for certainty as to who was more accurate, although the

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<sup>304</sup> Ibid. 32.

<sup>305</sup> SUPP 6/163. Annual report of the president. 1908. 40.

Government plainly stated that the Chemist, War Department had the final say in all inspections of irregularities.<sup>306</sup>

The tests from Vickers and Armstrongs for nickel versus nickel-chrome forgings ordered in 1907 were delivered as forgings to Woolwich, which turned and rifled them. The Elswick forging was received and passed in 1907, but the Vickers forging was low in manganese, and was passed only provisionally. The tests were postponed in June 1908. It was decided that the test should proceed on the lines of a test on inner liners removed from guns. The CSOF had two liners of carbon that could be run against, one that was removed due to improper rifling without being fired, and another, a 12-inch gun which was removed due to it being worn out. These would also be used in the hammer tests that Vickers and Armstrongs used to test items.<sup>307</sup>

### **Continued Vickers Problems**

A 1909 report stated that even with the introduction of new techniques, Vickers was still having troubles. ‘Although indications of green had been found in many of the fractures, they were not nearly as common as observed previously, with the proportion having been reduced from

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<sup>306</sup> SUPP 6/65. Annual reports of the president. 1905. 13.

<sup>307</sup> SUPP 6/163. Annual report of the president. 1908. 41.

about 20 per cent to about 10 per cent. In the same way the number of laminated fractures had dropped to about 50 per cent.<sup>308</sup>

Even worse for Vickers, ‘At a meeting which was called for the purpose of considering the introduction of nickel steel into gun construction, they (Vickers) at that time thought that a minimum breaking stress of 45 tons could be obtained, but, as they pointed out at the meeting, their experience of nickel steel to this analysis in large masses was not very great, and it was not until they got into the general manufacture of this steel that they found that a modification in the minimum breaking stress would be desirable in order that delays should not occur in the manufacture of heavy forgings entailing the use of especially big ingots’<sup>309</sup> It was eventually revealed that Vickers could only guarantee 30 tons elongation, when 45 tons elongation was the specification that Armstrongs was able to produce. This elongation was the second of three failings of Vickers to produce acceptable steel, and a primary reason for Vickers guns failing in service with high velocity designs.

### **Metallurgical Flaws from Vickers**

Vickers-made guns under new steels had been rejected first and foremost by the inspectors for streaks, cracks, and flaws. Streaking did not

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<sup>308</sup> SUPP 6/164. Annual report of the president. 1909. 58.

<sup>309</sup> SUPP 6/65. Annual reports of the president. 1905. 30.

have depth and therefore was not a failure on its own, but the Inspector of Steel considered cracks, flaws, and seams as rejectable defects.<sup>310</sup>

Errors in steelmaking appear to have been the result of the different type of furnace used. Vickers used the older vertical furnace as well as a horizontal furnace, whilst Elswick and Openshaw, both Armstrongs plants, used low horizontal furnaces. Openshaw at Manchester ‘might be partly accounted for by the forging being revolved while heating.’ Vickers, though, were in the process of investing in a new furnace at River Don.<sup>311</sup> The issue, although not explicitly clear, was that heat treatment and annealing seemed to be the real problems for Vickers, once the earlier issues of contaminated crucibles was overcome.

Vickers had several failings in building plant. Vickers had an open-air plant, where guns were susceptible to breezes, whereas the Royal Gun Factory was concealed and controlled. Also, Vickers were less accurate with their pyrometer, and did not protect it from flames, and therefore it was not as accurate as the pyro-coupler pyrometers used by the Royal Gun Factory. This could lead to distortion.<sup>312</sup> This was brought up, as the air

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<sup>310</sup> SUPP 6/66. Annual reports of the president. 1906. 142.

<sup>311</sup> SUPP 6/67. Annual reports of the president. 1907. 62.

<sup>312</sup> SUPP 6/166. Annual report of the president. 1911. 45.

actually made one side cooler, and therefore bent, causing a 6-inch gun to be damaged late in 1911.<sup>313</sup>

Plant was not only the equipment in Vickers works that failed the company's guns. Vickers Don River had first relined a 12-inch gun in 1901, and it had all sorts of shoddy workmanship when it was exposed at Woolwich for relining in 1905.<sup>314</sup> This poor first relining in 1901 was hidden by Vickers intentionally from the inspector, and it was believed this was why the gun only had 30 shots in its life. The 1905 report was filled with 12-inch guns from Vickers failing. Tolerances were noted as a primary issue. It must be noted that many of these guns were cracking due to manufacturing imperfections of .15 inches and below. The failures of these guns showed to many in the Government and industry that the British design decisions to maintain tight tolerances were in the long term the best route. Poor workmanship was the primary cause of the shortcomings, and the lack of governmental inspectors during the building process was the primary oversight.<sup>315</sup>

Of 110 12-inch Mark IX guns made in total, the only failures were of Vickers manufacture: five of 36 they supplied failed. Vickers seems to argue in a 7 April 1908 report that this was due to the oil tank for

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<sup>313</sup> Ibid. 46.

<sup>314</sup> SUPP 6/65. Annual reports of the president. 1905. 18.

<sup>315</sup> Ibid. 17-18.

quenching being too cold, although this was not commented on by the Board.<sup>316</sup> The only eight forgings rejected for chemical reasons by the Chief Inspector, Woolwich in 1909 came from Vickers.<sup>317</sup>

By 1908 of the 485 guns of 12-inch to 7.5-inch that had been made, 15 had split their liners, or 3.1 per cent. Vickers later admitted that their treatment was not satisfactory.<sup>318</sup> By 1912, the trend had reversed, and Vickers along with the rest of the trade were making guns that did not crack.

### **Bureaucratic Matters with the Use of New Materials**

The Government bought a great amount of steel for the use of relining guns that had been worn out. In 1906, 'The NOO was buying nickel steel tubes for future use, and presumably his stock of carbon steel tubes would be used up before the nickel steel was taken into use.' This was for the larger (6-inch and above) tubes at Woolwich, for relining, and possibly for new build work. It is unknown how large this stockpile was, but it could possibly be calculated from the first use of relining large guns with nickel at Woolwich.<sup>319</sup> Unfortunately, this information does not seem to

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<sup>316</sup> SUPP 6/163. Annual report of the president. 1908. 18.

<sup>317</sup> SUPP 6/164. Annual report of the president. 1909. 54.

<sup>318</sup> SUPP 6/163. Annual report of the president. 1908. 16-17.

<sup>319</sup> SUPP 6/66. Annual reports of the president. 1906. 76.

survive, as the records of the relining inspection appear to have been culled before being deposited in the National Archives.

The design of the 4-inch BL Mark VII was a significant departure in many regards from previous smaller guns. The contract solicitation stated that this 4-inch, 50 calibre gun was to be made out of nickel steel, in the specification S/22, and did not require a fully wired barrel or both inner and outer A tubes, although it did require the gun to be easily relined and the rebuilding had to be clearly indicated.<sup>320</sup> In addition, 'the longitudinal strength must be such that the gun would be safe with a circumferential crack in the chamber'. The 4-inch Mark VII had several entries from Elswick, Vickers, Messrs Brown, the Royal Gun Factory, and Coventry, the latter being rejected outright.

The learning curve for producing forgings of quality was very different for different manufacturers. Elswick had almost no learning curve and had few rejections. Cammell went from 1 in 3 rejections to almost no rejections in less than a year. Vickers simply did not bother to make nickel steel in this period, as was mentioned in the previous section. Forgings for Woolwich provided by Jessop, Cammell and Beardmore had all failures.<sup>321</sup>

This period of experimentation from 1903 through early 1907 showed that if anything, the bureaucracy of arms procurement was flexible

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<sup>320</sup> Ibid. 28.

<sup>321</sup> Ibid. 56-57.



and willing to take risk, both financially and technologically. Throughout the period, the Ordnance Committee was willing for each company to produce their own nickel steel recipes, and moreover, was even willing to let them harden or not harden to their own content. These truly was experimental procedures with nickel steel, and the Ordnance Committee were trying to learn as much as possible, as quickly as possible, while relining could always occur later.

This meant that the 12-inch 40 and 45-calibre guns would all have to be relined within a few years to the desired standard steel, but until then, a great deal of experimentation would take place. This meant that the committee were essentially back loading the supply chain, but also recognized nickel was better than ordinary steel.<sup>322</sup> Through all of this, the Admiralty, and especially the Director of Naval Ordnance and Controller of the Navy would have had not only to approve but also actively to pursue this approach, as the majority of the experimental material came out of their annual Vote 9 for Ordnance.

There was one instance, though after the acceptance of nickel steel when the Vote, due to financial reasons had a veto over design. In 1909, the price of new 12-pr 12 cwt guns was proposed at £100 for nickel, versus £75 for carbon. The Director of Naval Ordnance sent a letter to the Board

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<sup>322</sup> SUPP 6/65. Annual reports of the president. 1905. 27.

asking for guidance. The Board recommended buying carbon in this instance.<sup>323</sup> This was the only instance ever cited in the President's digested report when such a request was ever made.

It was not only internal experiments that the Committees had to report on. Inventions submitted to the board were all too common. To cite what might be the most fanciful, 'The Director-General of Ordnance of the 3<sup>rd</sup> February forwarded a communication from the Consul-general, Christiana, with reference to a gun invented by Professor Birkeland, which would discharge projectiles by the force of electro-magnetism. The Committee stated that they did not consider anything would be gained by an inspection of Professor Birkeland's invention.'<sup>324</sup> It would not be until the second decade of the 21<sup>st</sup> century that Birkeland's idea would come to fruition and the electro-magnetic rail gun would be built.

Experiments were usually ordered and directed by the subcommittees of the Ordnance Committee/Board. Some of these committees were not as well represented as the general committee, although they could be diverse in their own regard. For instance, the temporary Field Artillery Committee of 1901-1905 that the 13-pr and 18-pr were developed from was brought back as a permanent subcommittee under the Ordnance Board in October 1907. The subcommittee was

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<sup>323</sup> SUPP 6/164. Annual report of the president. 1909. 39.

<sup>324</sup> SUPP 6/61. Annual reports of the president. 1902. Appendix 45.

represented equally by the field and garrison regiments, and by two members of the Ordnance Board, who were supplemented by one officer of the Royal Engineers, one Royal Garrison Artillery representative, and (for mountain artillery) one India representative.<sup>325</sup> Each of these men in the normal service, would have had little to no contact between each other, although when in committee together they were able to add to each other's experiences and could help solve problems from different angles. It was representative of many of the subcommittee compositions.

### **Wire Manufacturers**

It was not only gun steel makers that had to deal with the increasingly stringent tests. Gun wire came under heavier scrutiny after incidents in 1902 of higher trace elements such as manganese and sulphur. The minimum tensile strength was raised from 110 tons to 117 tons, without altering the maximum specification.<sup>326</sup> In 1903, gun wire manufacturers Fox & Co, The Whitecross Co, and Hill & Co all raised their prices complaining an overly rigid specification regarding carbon and manganese.<sup>327</sup> In addition accuracy limits of wire were .002 +/- before March 1903. This was replaced with a specification of .001 +/- although it

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<sup>325</sup> SUPP 6/544. Extracts from proceedings Royal Artillery Committee. 1.

<sup>326</sup> SUPP 6/61. Annual reports of the president. 1902. 11.

<sup>327</sup> SUPP 6/62. Annual reports of the president. 1903. 107.

was rescinded after difficulty in producing such accuracy from the trade.<sup>328</sup>

There is little known about this tier of suppliers. Even names of companies are difficult to come across, and scant receipts were listed in the Woolwich annual audits. The science behind all of this was contained in Longridge's theory of wire winding, the basis and theory used by the Chief Superintendent of Ordnance Factories for wire winding guns.<sup>329</sup>

Wire was tested to 65 tons before being wound, and guns were rarely wound over 40 tons.<sup>330</sup> Streaking was a problem in some nickel forgings in the early days. Cammell had the worst problem, where Elswick Manchester had few, and it was not observed in Elswick forgings. The larger the forging, the larger the problem. This was caused by a lack of homogeneity.<sup>331</sup>

According to the specification of 1913, '80 per cent of the wire supplied is to be in lengths of not less than 1,514 yards, and the remaining 20 per cent in lengths of not less than 1,000 yards. The wire must be regular in section, 0.25 inch wide and with a limit of +/- .001 inch for width and thickness.'<sup>332</sup>

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<sup>328</sup> Ibid. 108.

<sup>329</sup> SUPP 6/164. Annual report of the president. 1909. 43.

<sup>330</sup> SUPP 6/165. Annual report of the president. 1910. 31.

<sup>331</sup> SUPP 6/66. Annual reports of the president. 1906. 141.

<sup>332</sup> SUPP 6/168. Annual report of the president. 1913. 313.

This is an area on which much more research needs to be done, although it is beyond the focus of this study.

### **Joint Design**

What might be the most novel aspect of British design was the nature of inter-service rivalry, or lack thereof. As a quick recap of Chapters Two and Three, the Ordnance Committee/Board was made up of an equal mix of senior officers from both services. Therefore, ordnance designed to mount on battleships in no small measure had input and refinement at the specification and inspection levels by army officers. As well, all guns until 1911, and effectively again after 1913, were ordered by the Director of Army Contracts. The Admiralty had some independence of contracts in the interlude. Unified contracting became a huge asset to the Government in implementing new materials and specifications across all systems. In addition, it meant that Whitehall talked to industrial suppliers with one unified voice, which eliminated bidding against each other by the services, a requirement of the Treasury.

At the start of the period under analysis, in 1901 the general process of design was that the government, usually the Ordnance Committee, asked for a design from the trade based on a certain sized bore and ballistic quality. The submitted designs were then scrutinized by the committee,

who then accepted, rejected or asked for a rework, and often CSOF picked the best of each design as a composite of multiple designs from multiple designers to be produced in its entirety by the firm that account for the most of the revised design. The designs were then ordered to trial, which seemed to be done differently for each new gun, and no generalizations can be made about this process. Once it was accepted, all firms could then bid on building the gun.

Very few guns, if any, were the product of perfect designs that the government accepted outright. Evidence shows that if anything, more technical knowledge of things such as breech chamber design and rifling were the near exclusive purview of the government. This changed over time, and by 1910, designs were more set in stone and based on solid principles. Many guns after about 1908 simply incorporated previous designs in a larger size, or with a modified chamber, etc, to meet the need of the service.

According to the Ordnance Committee ‘The conditions required having been formulated, designs obtained, carefully considered as to safety of construction, &c., and the probable ballistics calculated, it is then necessary to have a trial gun or guns manufactured.’<sup>333</sup> In addition, as technology changed faster, the work also increased. In 1902, the President

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<sup>333</sup> SUPP 6/63. Annual reports of the president. 1904. 1.

of the Committee stated that ‘The work of the Committee, and the number of subjects referred to them, have increased from year to year, and undoubtedly will do so still more, as our armaments must be kept up to the rapid advances in war material made by all Great Powers. Application has been made for the appointment of an additional Member so that increasing amount of Sub-Committee work may be properly coped with’<sup>334</sup>

The issue of proper staff office space remained a large issue in 1905. The committee believed that they were not able to provide the analysis expected of them in the quantity needed with their current resourcing.<sup>335</sup> This demonstrates just how much more advanced and time consuming the task of engineering new ordnance utilizing new propellants, steel, and design was and the stresses entailed in properly analysing them. In addition, it showed that the British Government continued close scrutiny over designs as time progressed.

### A Standard Ordnance?

There was a rapidly advancing opinion by the end of the first decade of the century that naval guns were actually quite different from coastal defence. Naval guns put a premium on weight, size, etc, and as well, that the electronic firing mechanisms were better suited for naval guns where

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<sup>334</sup> SUPP 6/61. Annual reports of the president. 1902. 99.

<sup>335</sup> SUPP 6/65. Annual reports of the president. 1905. 1.

trained engineering officers were available. Coastal batteries might not have the engineering support available when a malfunction occurred for the more precise electronic mechanisms.<sup>336</sup> This was not always apparent in gun orders, with frequently the same gun was chosen by both services. It appears that a case by case basis for regional needs and availability for garrison artillery had a factor in the actual orders, although this was either not written down, or has now been destroyed in the records.

As the coastal artillery had been almost wholly equipped by the time the transition to high velocity guns came to naval ships, the cost to benefit ratio did not justify replacing all guns on land forts. Also, the particular usage of coastal guns meant that they had a different economy. This was due to limited rounds in annual shell expenditure. As well, shell ranges were limited to the location of the fort. Finally, the coastal mountings were not able to take the force of the increased energies created by the increased pressures. In the end, the driving requirement of coastal artillery was that accuracy was more important than penetrating pressures.<sup>337</sup> The end analysis appears strong, as many of the guns placed in coastal fortresses in the early 1900s were still there 50 years later.

It was not only the home services that challenged design to standard ordnance. Members of the Government, especially the Indian Secretary, in

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<sup>336</sup> SUPP 6/61. Annual reports of the president. 1902. 3.

<sup>337</sup> SUPP 6/63. Annual reports of the president. 1904. 59.



1905 challenged the need for a wire gun, stating that technology had sufficiently advanced that single casting could now be done in an efficient way. Armstrongs were the only ones that had experience in solid, built up manufacture, and argued that although the relining was easier, it was still a better gun with wire. The basis for block gun construction as used by every other power was that only the breech side of the barrel needed to be replaced as it was the only side that usually was affected by erosion.<sup>338</sup>

### **The Ordnance Committee to Ordnance Board**

In a note to the preface of the 1908 edition of the Annual Report of the President, it was stated that on 30 October 1907 the Director of Artillery decided to amalgamate the Ordnance Committee with the Ordnance Research Board, and the new title would be the Ordnance Board, effective 1 January 1908.<sup>339</sup> This seemingly trivial change does appear to have accompanied some large modifications. The largest modification limited the role of civilian advisors. These men had previously been part of the committee since at least 1881. This new board in reality weakened the Master General of Ordnance in favour of the service ordnance chiefs, although it was not explicitly designed to do so.

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<sup>338</sup> SUPP 6/65. Annual reports of the president. 1905. 114-116.

<sup>339</sup> SUPP 6/67. Annual reports of the president. 1907. 1.

The largest single task of the board was managing and directing research and design for all British ordnance. The research and design budget was essentially directed by the Board, and almost all of it was spent on tests at Shoeburyness and Woolwich, and to a lesser extent Aldershot (and Bisley for small arms). The experiments were paid for out of Army and Navy Ordnance Votes, Vote 9. This joint experience meant that both the Army and Navy could benefit from each other's experiments, both in cost and time. It is really difficult to overstate the benefit this joint committee had on designs. It meant that Royal Navy guns were identical to their equivalent British Army guns and vice versa.

Ballistics were considered equal within the realm of coastal artillery and naval artillery, and therefore it can be assumed that the contemporary reports on naval artillery were covering their army counterparts. This was important especially in operations, as naval research could be used in siege applications, which utilized weapons of 6-inch and above.<sup>340</sup>

### **Holding Suppliers Accountable**

Inspection and management of supplier deliverables was a key element of the Government's role in verifying that what was delivered and paid for was the same as what was ordered. The Government had no

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<sup>340</sup> SUPP 6/63. Annual reports of the president. 1904. 3.

problems with holding the suppliers of ordnance accountable for mistakes. This seems like an obvious action, although even today inspection rights are often not fully exercised, for the sake of keeping contractors content. This was important not only to ensure that the product ordered was received to plan, but also to eliminate any corruption that might occur between supplier and buyer.

Inspection was especially important in warlike stores. The tolerances required as well as the use of materials that were not considered commercial made it all the more important. Even more than most, guns that failed had a high chance of injuring or killing, which even in Edwardian Britain could cause scandal that would undermine the entire system. The tolerances for the Mark IX 12-inch gun were seven thousandths of an inch. That is under the size of two human hairs (.004). And as mentioned earlier, wire had a tolerance of just .001 inch. This tolerance was normal throughout the period in question.

Inspection also included a feedback loop that gave manufacturers some way of improving their products. This came through both comments on failed guns, but also as part of conferences with gunmakers that occasionally occurred. One such event was the third conference with gunmakers which occurred on 8 Feb 1910. The conferences were

important for unwritten communication that was otherwise always written.<sup>341</sup>

Unfortunately, because of this medium, no notes appear to survive on what was said at any of the pre-war meetings with gunmakers.

At other times, some firms preferred to self-regulate and self-inspect. In a rare case, sometime after 23 Jan 1911, Messrs Firth 'Had since declared their inability to produce satisfactory billets for gun forgings, and it had been proposed to remove their name temporarily from the list of Contractors on this account.'<sup>342</sup> It must be stressed, that this case was rare, and was also the only uncovered instance of this occurring.

### **The Inspector of Steel**

The most important three individuals in the inspection process were the Inspector of Steel at Sheffield, the Chief Inspector, Woolwich, and the Chief Superintendent of Ordnance Factories.<sup>343</sup> The Inspector of Steel at Sheffield had the closest relationship with steel manufactures, not least which because he was stationed at the heart of the area where almost all the producers were located. The Inspector of Steel regularly visited plants and oversaw the inspection staff of the government. He was the first to point out oddities that could indicate trends in the industry as a whole. For

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<sup>341</sup> SUPP 6/165. Annual report of the president. 1910. 5.

<sup>342</sup> SUPP 6/166. Annual report of the president. 1911. 71-72.

<sup>343</sup> SUPP 6/163. Annual report of the president. 1908. 40.

instance, titanium was found to be a source of rejection due to it showing ghost lines in castings, and Cammell Laird was banned from using it by the Inspector of Steel in Feb 1912.<sup>344</sup> Titanium as a metal was almost unheard of by this period in the commercial world, and would certainly have been too expensive or use in anything but the most expensive alloy steels.

Inspection acceptance was set by policy to be on a case by case basis, with errors in manufacture being ‘treated on its merits’<sup>345</sup> The acceptance of guns not meeting specification became a major claim on time and resources by 1902. In that year alone the committee looked at 120 guns that were improperly manufactured in one form or another, and generally accepted the guns at a reduced price based upon the shortened life caused by manufacturing defects, assuming that they passed proof. Many of these initial rejections were based upon grooves that were too deep, and thus the driving bands might cause increased erosion, and other similar issues.<sup>346</sup> Almost all were caused by machinery error and not metallic or casting failure in earlier years, but, as the new alloy steels were introduced, the errors shifted more to chemical failures in the steels themselves.

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<sup>344</sup> SUPP 6/167. Annual report of the president. 1912. 553.

<sup>345</sup> SUPP 6/60. Annual reports of the president. 1901. 4.

<sup>346</sup> SUPP 6/61. Annual reports of the president. 1902. 16.

## Other Inspections

This chemical inspection was made more difficult by the way that particular trace elements were distributed over the pour of the casting. Carbon contents and other trace elements appeared in different concentration between the part of the ingot at the bottom and the top of the pour. For instance, the lower portion of the ingot contained more trace amounts than the top of the ingot, causing testing to be conducted at both the breech and the muzzle of each forging before and after annealing.<sup>347</sup>

Rejections of steel for forgings came under increased scrutiny. A seemingly vague area in contract clauses forced the Chief Superintendent to purchase forgings that the Chief Inspector Woolwich had subsequently rejected after working. The Treasury Solicitor became involved when Armstrongs contested the rejection. The difference arose with the rejection based upon the lack of passing tests, and not due to flaws, which the company stated was not their responsibility. The specifications were amended to include more stringent carbon content amounts as well as more stringent ductility tests.<sup>348</sup>

The seemingly obvious course of comparing the gun under inspection to the contracted gun was not even an easy task. The Chief

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<sup>347</sup> SUPP 6/60. Annual reports of the president. 1901. 87.

<sup>348</sup> Ibid. 9.

Inspector Woolwich had to set up a contractual policy that the Government was to send a set of drawings with every contract, and that these drawings were the most up to date and contemporary for every contract released.<sup>349</sup> In addition, one of the key instruments for inspectors was the use of *gutta percha*. *Gutta percha* was used as a way of making impressions on the internal areas of guns, and was especially useful in uncovering imperfections or coppering. *Gutta percha* came from Malaya (now Malaysia) and was a type of latex rubber.

### **Many Forms of Informal Inspection**

The board received several forms of official and less than official reports on how ordnance was performing in the field. The largest source of official information came from casualty reports. There are many incidents in the annual reports of the President of the Ordnance Committee/Board that highlight issues that obviously were considered important. All failures of guns that included damage of equipment or serious injury were reported to the Committee, as well as any manufacturing error that did not comply with the specification. This latter form of reporting took up by far the most time in Committee.

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<sup>349</sup> SUPP 6/164. Annual report of the president. 1909. 39.

Many minor manufacturing mistakes that pertained to rifling went subsequently accepted. The Ordnance Committee, not being able to prove that a gun would fail, gave the manufacturer the option to have the guns go to proof 'without prejudice to any decision that might come to.' When given the choice, manufacturers almost always chose to have the gun proofed, and almost always, the guns were accepted. Artillery tubes were simply too expensive, and took too many resources, and a repair was no guarantee that the piece would be any better than the first attempt. It made more business sense to have the guns proofed and accepted, as a destructive proofing was mathematically unlikely with the most up-to date gun designs being challenged.

The inspectors at Sheffield were some of the busiest inspectors in the entire Government. The 1904-1905 forging inspections reveal a great deal about the size and health of the British steel and ordnance industries. Many rejections of carbon forgings occurred, due to the lower limits being more heavily investigated and enforced. Elswick had 1.6 per cent rejected (13 of 820), Elswick, Manchester, 14 of 242, Vickers, 48 of 744 (6.5 per cent), Cammell, 12 of 128 (9.4 per cent), Taylor, one of 21, J Bown, zero of 15, Spencer, one of three, Beardmore, zero of four, Ince, zero of two, Darlington, zero of one, and Jonas and Colver, zero of two for an overall rejection rate of 90 out of 1998 inspected.



### **1908 Inspections: a Cross-Section Example**

All forgings sent to the board in 1908 for decision were accepted. seven carbon steel and seven nickel steel. What is most significant, is that no carbon steel was inspected for the use of 'A' tubes in 1908, showing that, firstly Vickers submitted no tubes for the Royal Gun Factory; and secondly, that the entire industry from the smallest suppliers to the largest had transitioned to nickel steel that they were sending to Woolwich for the use of the Royal Gun Factory.<sup>350</sup>

In addition, 1908 caused a mixup in how forgings were accepted or rejected. Instead of the Board deciding on what should be accepted or rejected, the Director of Artillery, WE Blewitt, requested that the respective service heads have decision, not the board. This gave more decentralized power, and did not come with a reason for such a change.<sup>351</sup> Before, the Board had little interfered with and almost never disagreed with the service heads. Why Blewitt insisted on this is not articulated in the archives.

### **New Naval Inspection after 1911**

The devolution of inspection to the services led to a small change for naval billets being inspected. Naval service had discs cut off billets

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<sup>350</sup> SUPP 6/163. Annual report of the president. 1908. 37.

<sup>351</sup> Ibid. 35.

starting in 1911 for testing of steel, yet this was rejected by the land service for several reasons. First, the billets for Land Service were so much smaller, second, land billets were solid 99 per cent of the time, whereas naval ones were hollow. Third, the rejection rate for smaller billets was much less, and fourth, the delay would not be worth it.<sup>352</sup> The 1911 specification was that all forgings for guns of 8-inch and above had to be hollow forged.<sup>353</sup> Before being forged, the forgings had been cast using the sand method.

It became a question of who had discretionary powers to accept the Vickers forgings with high silicon contents. The Inspector of Steel had already accepted forgings that were well in excess of service limits. The Chief Inspector, Naval Ordnance, was against this as several forgings that had been accepted were later given unsatisfactory results.<sup>354</sup> The Superintendent of Research was not convinced by the Vickers excuse, and believed that the percentage of silicon reacted with the percentage of carbon, and that this combination, combined with 'indifferent heat treatment' was the main problem with the Vickers issues with silicon and rejected forgings. The annealing temperature for 0.406 per cent silicon in nickel steel was 1,250 degrees (F), which was within 20 degrees of the

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<sup>352</sup> SUPP 6/166. Annual report of the president. 1911. 72.

<sup>353</sup> Ibid. 75.

<sup>354</sup> SUPP 6/163, 38.

maximum for the integrity of the steel without degradation. Therefore, Vickers's arguments for raising the silicon content above 0.25 were rejected.<sup>355</sup> Vickers blamed the excessive amounts of silicon in gun forgings on the residual oxygen from the 'oxygen originally dissolved in the fluid steel' The silicon was added to remove non-metallic substances that formed silicates, which then could be slagged off.<sup>356</sup>

The Inspector of Steel believed in 1909 that the hands off approach that was generally adopted towards manufacturers was not always the best because manufacturers heated tubes before shrinking, sometimes heating them higher than the annealing stage, which would have altered the hardness and other factors. The Board was still unwilling to give much more guidance out of a seeming fear of stepping on toes.<sup>357</sup>

### **Paying for Wear and Tear**

Gauges and models were being worn out at Woolwich from contractors using them to adjust their guns before formal delivery to the Chief Inspector Woolwich. This caused the Chief Inspector Woolwich to suggest in particular an increase in tolerance to the breech of several guns for the sake of ease of setup as well as the increased life to his gauges,

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<sup>355</sup> Ibid. 39.

<sup>356</sup> Ibid. 38.

<sup>357</sup> SUPP 6/164. Annual report of the president. 1909. 46.

which the Government provided for their use.<sup>358</sup> Gauges were not cheap and copies were not widely distributed due to this. A new set of gauges for the 13.5-inch Mark V would have cost £4,500, £1,500 for the 6-inch Mark XII, for the 4-inch, Marks VII and VIII, £1,500, for a total cost of £7,500 over three guns.<sup>359</sup>

The Committee through the Inspector of Steel also saw requests for experimental building techniques in guns slated for operational use. One of these was listed in a 12 April 1906 note in which the Chief Inspector Woolwich informed Elswick that ‘in order to shorten time of manufacture, an extra wire may be used with a tension of 20 to 25 tons, to be turned down to suit the interior of the ‘B’ tube or jacket, the number of effective wires not being altered.’<sup>360</sup>

### **The Last Conference**

The last conference with gun-making firms before the end of peace was held on 4 Feb 1913 with Openshaw, Coventry, Brown, Firth, and Cammell. The meeting was called to discuss what to do with those forgings that did not pass Admiralty specifications as well as the delay in manufacture of heavy guns.<sup>361</sup> As with all of the conferences called by the

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<sup>358</sup> SUPP 6/167. 149.

<sup>359</sup> Ibid. 150.

<sup>360</sup> SUPP 6/66. Annual reports of the president. 1906. 94.

<sup>361</sup> SUPP 6/168. Annual report of the president. 1913

Ordnance Board, the results were not kept and the notes do not exist today.

The inspection staffs knew first-hand the pulse of the industry. This was primarily due to visits and constant contact. This allowed the inspector to notice things. An example of this was through a tour of Vickers by the Royal Gun and Carriage Factory metallurgist from August 1912 that showed that the private firms of Darlington and Vickers, especially the latter, used carbon testing in a way that was more efficient and allowed more throughput than the Royal Gun Factory, but was not as accurate as that used by the Royal Gun Factory.<sup>362</sup>

### Donaldson

Arguably the most important person in all of this was not an officer at all, but a civilian engineer, the Chief Superintendent of Ordnance Factories at Woolwich, Hay Frederick Donaldson. Donaldson was one of the most highly regarded engineers in the country and ran government designs for all ordnance from 1899 until his untimely death in the sinking of the HMS *Hampshire* in June 1916. Donaldson and his team at Woolwich designed the ballistics, pressures, and specifications for all guns before they were sent out to the trade for final manufacturing design. This

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<sup>362</sup> Ibid. 311–312.

has been completely forgotten by historians to date as it does not fit in with the corporate histories that consider the designs anything but their own.

### **Rejected Guns**

Government inspectors of ordnance often did not reject guns outright. The proposed rejected guns were sent to the Ordnance Board to decide the fate of the individual piece, making judgment on the merits of the flaw, as well as the position of the service. Often the gun was accepted, although with a substantial fine based upon the shortened life.

Some fines were quite severe, with an example being a 9.2-inch Mark X gun, No 160 that had two widened grooves, and tool marks, which warranted a reduction of £350 in the price, a substantial fee that certainly would have eliminated any profit.<sup>363</sup>

Another Armstrongs gun, No 162, was fined for exceeding the limit of bore measurements for 22 inches of the barrel, thus incurring a fine of £150. This fine was punitively high because the Ordnance Committee saw that this was a recurring theme with Armstrongs and that this might be a punitive measure to clean up the quality being submitted to the inspector.<sup>364</sup>

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<sup>363</sup> SUPP 6/60. Annual reports of the president. 1901. 39-40.

<sup>364</sup> SUPP 6/60. Annual reports of the president. 1901. 40.

Problems with the same model often could vary widely due to how extreme the problems were. Armstrongs guns numbering 176 and 178 both exceeded bore measurements, and one was fined £250 and another £40 for the errors.<sup>365</sup>

It was not just Armstrongs that had guns fined for errors. Vickers submitted gun number 237, which had a groove .05 inches too deep, which caused the committee to reject it and require a new inner 'A' tube, a costly mistake.<sup>366</sup>

The contractors not surprisingly wanted a change to the steel specification so that it could be made cheaper. In a meeting, attended by the Chief Superintendent, Ordnance Factories, Superintendent, Royal Gun Factory, The Chief Inspector, Woolwich, and the Board, they saw objections to virtually every point, including that the proposed pieces would not 'materially affect prices'. These objections were concurred with by the Director of Naval Ordnance and the Director of Artillery.<sup>367</sup>

### **Corruption**

In that last regard, no case of outright corruption was seen in all the records viewed, although some dealings between Archibald Gordon Henry

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<sup>365</sup> Ibid.

<sup>366</sup> Ibid.

<sup>367</sup> SUPP 6/165. Annual report of the president. 1910. 58.

Wilson Moore as Director of Naval Ordnance and the trade, especially Vickers, were suspiciously friendly. This is the only case. A.G.H.W. Moore seems to have been swayed more by contractors than his predecessors. Within a month of his arrival in December 1909 as Director of Naval Ordnance, there were requests from Cammell for a new meeting of all the steelmakers to change specifications of steels. This was shot down by the Board. The Director of Naval Ordnance still held a conference at the Admiralty on 27 June 1910.<sup>368</sup> He seems to have thrown several crackpot ideas out in the first months of 1910. He, at the request of the contractors, proposed suspending new regulations for the new steels, on 30 Nov 1910. This would have been a year into Moore's term.<sup>369</sup> Moore also wanted to dispose of the traditional role of Woolwich. Moore was addressed in a letter from Donaldson showing his dismay at possibly giving the trade the chance to reline guns for the Admiralty. Donaldson stated that historically this had come up, and it was decided to stay at the Ordnance Factories for this work not only for the consistent quality, but also for the research derived from failed and worn guns. He does not seem to have been given comment back, and thus policy did not change.<sup>370</sup>

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<sup>368</sup> SUPP 6/165. Annual report of the president. 1910. 56.

<sup>369</sup> SUPP 6/166. Annual report of the president. 1911. 62.

<sup>370</sup> SUPP 6/165. Annual report of the president. 1910. 40.



## Conclusion

The technical requirements of ordnance drove the decisions of what would eventually be produced by industry. Correlli Barnett has argued that ‘defective technology, reflecting the scientific and technical backwardness of British industry, was not the only ingredient in the British failure’ to destroy everything in its path militarily.<sup>371</sup> This argument that has been put forth that Britain was technologically behind, or even backwards could not be further from the truth. The British fleets by 1914 mounted the largest guns afloat (15-inch), and the British Army had the most powerful field guns in the world.<sup>372</sup> Only those who truly have misinterpreted the facts could see otherwise. British industry, although slow to implement some elements, was still able to produce guns of the highest quality. Britain had the only growing armaments industry in Europe, with four private companies making armaments for the newest British battleships, up from two just a decade before.

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<sup>371</sup> Corelli Barnett. *Engage the Enemy More Closely*. New York: W.W. Norton & Co. 1991. 7.

<sup>372</sup> Hansard *HC Deb 5 March 1907 Vol 170* Statement by Mr Arthur Lee. 627.

## **CHAPTER SEVEN: TECHNICAL EVOLUTIONS IN ARMAMENTS,**

### **1900-1914**

The evolution of ordnance has been shown in the first five chapters to be a developmental process. Generational changes occurred in the period between 1900 and 1914 exceeding those in any equivalent period in British history. This chapter will break individual systems down for further development to demonstrate the scientific prowess of the ordnance industry as a whole at the time as well as the problems inherent in pushing the boundaries of industry and science as it pertains to larger guns used by the Royal Navy and the Royal Garrison Artillery. As will be demonstrated, most of these problems were easily solved, although some took much longer and required cultural, industrial, or management efforts to solve that are not obviously compatible with the simple explanations for problems given in popular literature such as Ian Hogg's *Allied Artillery of World War One*. Historiographically, picture books with vital statistics like Hogg's are popular with amateur historians who tend to quote un-validated information which is then perpetuated in later texts. The next two chapters in particular tackle some of these concepts with contemporary information that is directly from previously secret sources which often contradicts the standard narrative.

The next two chapters look at individual cases. This is important in understanding how these particular weapons performed when they were used, and problems or successes based upon their design, experimentation, and peacetime usage. The following also represents the transition from peacetime uses to wartime, and what exactly the British Army and Royal Navy went to war with.

What follows is a breakdown of the inspiration, need, development, and operational experiences of the ordnance that represented the British arsenal by July 1914. Not all of these guns made it to operational use, although those that did not were used to inspire future follow-on systems. In general, the chapter progresses from the 6-inch, Mark VII gun which was the design inspiration for almost all British guns in the twentieth century, to the evolution of naval main armament, followed by the secondary and coast artillery and smaller guns. The chapter then transitions to land artillery, first discussing field pieces, and ends with the siege artillery, including railway guns.

This chapter as well as the next are products of hundreds of hours of archival work that demonstrates the difficulties of summary comments to explain complicated technical challenges. This is especially useful to naval historians and illuminates the evolution of ship armament that has

been taken for granted how it has evolved and why. Many entries demonstrate this is not the case.

### Arguments of ‘Economic Decline’

Many historians since the 1970s have argued that Britain had been in a decline since the late Victorian period. Some place this as early as the 1870s. The general arguments follow a line that Britain was in relative decline industrially compared to neighbors as well as the new superpowers. Many of these arguments run in direct contradiction to the results of the analysis presented in this thesis. This does not necessarily mean that either case is incorrect. In addition, much of the literature written a generation ago has now been challenged by those such as David Edgerton, whose 1996 book *Science, Technology, and the British Industrial ‘Decline,’ 1870–1970* challenges the works of those such as CP Snow, Martin Wiener, and Correlli Barnett, as ‘much technocratic writing is not economic or technological history but the *cultural* history of anti-technology.’<sup>373</sup> Much of the writing of earlier scholars in general such as Barnett has not held up to the next generation of study. Edgerton especially has challenged the works of these earlier authors. His works

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<sup>373</sup>David Edgerton. *Science, Technology, and the British Industrial ‘decline,’ 1870–1970*. Cambridge: Cambridge University Press, 1996. 7.

such as *Britain's War Machine* (Penguin, 2011), *Warfare State: Britain, 1920-1970* (Cambridge, 2006) and *Shock of the Old* (Profile Boks, 2007) have put to bed many of the larger concepts of the field that have permeated through myth, lore, and academia for over a century.

Unfortunately for the topic though, ordnance is difficult to group into the wider general histories of economic and technical history as it is not a commercial item, and therefore cannot be summarized with the rest of the field of general study. The specialized study does not allow it to be grouped with almost anything else. The tolerances, high capital outlay, and single customer made ordnance and large guns in particular an industry that did not and still does not mirror general trends that might represent industry as a whole for a country, region, or even general time period.

### **The 6-inch Mark VII**

The 6-inch Mark VII was considered the most important gun of British ordnance between 1890 and 1914. This was due to it being the first large sized gun to be designed for use with cordite. The gun was the testbed for over a decade of research. This research spanned every part of ordnance from propellants and driving bands on shells, to the proper muzzle velocities for barrel life and the basis of all rifling experiments in the Cordite age.

The 6-inch Mark VII was the primary gun for testing new powders, especially the differences between the original Mark I Cordite the gun had been designed for, and a much improved Cordite MD (Modified Design). It was also the basis for the experimental powders that were not accepted for general service due to either their failures in testing, or industry not being able to produce enough quantities. One of these powders was called Cordite MDT, or Modified Design, Tubular. Many of these experiments proved how different propellants and muzzle velocities affected the life of guns. The 6-inch proved to be a preferred test bed not least because its moderate size mimicked large guns, but also because it was much less expensive to repair, reline, and replace than its capital armaments counterparts.

In one experiment conducted in 1905 at the very beginning of MDT, an attempt was made to see if certain powders gave improved ballistics and extended barrel life. It was discovered that Cordite MD gave a higher muzzle velocity, a lower rate of erosion, and greater accuracy than MDT. 'In any given gun the amount of erosion at 1 inch from the commencement of the rifling is mainly due to the weight of the propellant in the charge and is but little, if at all affected by its form (cord or tubular), or by the maximum pressure in the bore.'<sup>374</sup> The result hampered

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<sup>374</sup> SUPP 6/65. Annual reports of the president. 1905. 11.

investment in MDT as well as further research into different sizes and chemical compositions. This negative result put back the study of MDT by over half a decade.

### The Testbed Workhorse

The nickel steel issues mentioned in the previous chapter were first tested in full on the 6-inch Mark VII gun. Two nickel steel tubed guns were sent to the ranges at Shoeburyness on the Essex side of the mouth of the Thames to be used for proof and evaluation purposes. Gun 1034 had worn down after 803 rounds to a limit almost condemnable, but was still good enough to be used for projectile proof, a key role performed at the ranges. It was decided to continue firing until the gun was completely unserviceable, and then it would be relined after finding out more. Gun 1034 eventually fired 1127 rounds before being condemned.<sup>375</sup> These tests performed to condemnation were by far the most valuable tests, as they showed not only initial wear, but also how guns, materials, projectiles, and other variables affected wear, accuracy, and power over the entire life of the gun, not just the initial proof firings. Unfortunately, few guns were sentenced to a full life test, as it was not only expensive to fire a thousand

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<sup>375</sup> SUPP 6-67. Annual reports of the president. 1907. 10-11.

rounds, but also took valuable range space for extended periods as well as timely paperwork to record and calculate the individual rounds.

Based upon the results of the 6-inch Mark VII, scientists were able to calculate for how guns naturally decreased through wear the speed of shot as it left the barrel, also called muzzle velocity. This calculation was one of the most important for operational units, as it meant that, if all other things were constant, the changing muzzle velocity could be used to compute the flight length of the projectile, the distance covered over a certain time, and most importantly, at what setting to set time fuzes to effectively hit the target as the gun went through its normal usable life. A calculation was formed by deducing the decrease in muzzle velocity from proof guns. For 29 pounds of size 26 Cordite, decrease of muzzle velocity equalled  $15 + 0.175 \times \text{number of rounds}$  in feet per second. For 23 pounds of size 16 Cordite; the fall of muzzle velocity equalled 10 feet per second + 50 feet per second for every inch of overram. This translated meant that the tests showed in the case of the 6-inch gun that every shot wore down the barrel by .175 m/s in muzzle velocity. In distance this converted to 6 inches per firing less per second.<sup>376</sup> In other words, every time the gun was fired, the equivalent wear meant that the projectile would go less distance with the same kinetic energy (propellant).

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<sup>376</sup> Ibid. 11.



Tests such as these were extremely valuable for naval guns, where if wear rates were known, especially in turrets with multiple ages of guns mounted, the crew could calculate the distance and flight time without having to fire shots. These were key calculations in rudimentary analog computers and range finding equipment. It also meant that gunners needed an increasingly sophisticated grasp of high-level mathematics to get the most out of their guns, although unfortunately that is beyond the scope of this study.

### **Later 6-inch Guns**

The 6-inch class of guns were a symbol of the state of naval warfare from the 1890s until 1906. Battleships bristled with them to deter the new quick moving torpedo boats with the fast evolving self-propelled torpedoes. This changed with the introduction of *Dreadnought*, which introduced the all-large gun battle ship, and discarded much of the smaller ordnance. At the same time, it was recognized that the Mark VII was becoming obsolescent and newer models were needed to outfit torpedo destroyers and light cruisers to defend the new *Dreadnoughts*.

Part of the obsolescence was shown in the 1906 incident reports, which listed all failures for all services. Guns No 1996 and 2126 of 6-inch Mark VII failed on HMS *Grafton*. Number 1996 made by the Royal Gun

Factory cracked for 33 inches after 249 equivalent full charges. Gun 2126 was built by Elswick and fired 297 6/16 equivalent full rounds. This was composed of 3 proof, 6 full, and 4566 half charges.<sup>377</sup>

The incidences of cracking were important as it was often the best canary to demonstrate that designs were reaching obsolescence due to their inability to fire new rounds and new propellants at increased muzzle velocities and to withstand the new kinetic energies caused from increased breech and muzzle pressures.

### **Life Corollaries through 6-Inch Guns**

As the Mark VII aged, other 6-inch guns took over the research of full life charging. A 6-inch Mark XI gun had an estimated life of 1,000 estimated rounds. The change in muzzle velocity, like the Mark VII, was believed to be plotted through its life cycle. Full life firings showed that the performance during the first 400 rounds was equivalent to that of a new gun, although by shots 400–500 there was a distinct drop off. This information allowed designers to try new shells, especially in weight difference to ascertain if it made a difference, over the long term wear. The practice shells were four pounds lighter, 100 versus 104, and for some reason of ballistic coefficient, in worn barrels, they were the same to 100

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<sup>377</sup> SUPP 6/66. Annual reports of the president. 1906. 111.

yards, yet at 9,400 yards the practice shell fell 200 yards short in worn barrels.<sup>378</sup> It is likely that there was a direct link between the research conducted on the 6-inch guns and the eventual designs for the 13.5-inch gun and its success as a long life main gun. However much of the correlatory work that would prove such points is buried in test reports, and the designers would probably have simply seen it as an evolution themselves, without taking into effect the fusion of the combined experiment results.

6-inch guns were also used as test beds for the viability of certain design elements. The 6-inch gun, 50 calibre, Mark XI was designed by the Chief Superintendent, Ordnance Factories, HF Donaldson, with build ability specifically in mind, this being the key reason the design was accepted.<sup>379</sup> This was probably the first gun entering British service that took British industry specific factors as the primary design factor.

### 6-inch Quickfiring Guns

The Royal Navy had issues with the 6-inch quickfiring gun on HMS *Porpoise* in 1901. The fault was verified by inspection to a cartridge case jam. It demonstrated that the supply chain of shell casings in this instance

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<sup>378</sup> SUPP 6/67. Annual reports of the president. 1907. 26.

<sup>379</sup> SUPP 6/62. Annual reports of the president. Note: Appendix 1903. 31–32.

was a weak point.<sup>380</sup> The care of casings would become a greater issue, and this might have been the impetus for the original desire of the Royal Artillery reequipping committee to almost choose a caseless cartridge for the field guns. If this had occurred, it would have had a huge effect on the rate of fire that would have been available in the field. This is a perfect example of how circumstances regarding naval ordnance affected the design of army ordnance.

The rate of fire and pressure as well as the relative cost of replacement made 6-inch guns some of the first designs to benefit from the introduction of nickel steel into ordnance. In 1908 the drawing was changed for 6-inch Mark XI guns to replace carbon tubes with nickel.<sup>381</sup> This was one of the first designs to be converted to the new material with an existing pattern gun.

### **The Last 6-inch Guns**

In 1911 the Director of Naval Ordnance requested a new 6-inch 45 calibre gun that was lighter and more manoeuvrable than the present gun which was to be used on cruisers and other light vessels. This would become the Mark XII.<sup>382</sup> The initial design came from the Royal Gun

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<sup>380</sup> SUPP 6/60. Annual reports of the president. 1901. 47.

<sup>381</sup> SUPP 6/164. Annual report of the president. 1909. 35.

<sup>382</sup> SUPP 6/166. Annual report of the president. 1911. 19.

Factory, and not Vickers as also stated by some.<sup>383</sup> The design for the Mark XII was accepted by the Ordnance Board on 5 September 1911, as Royal Gun Factory design No 11,319. The entire process from needs request to approval took two months after the original Director of Naval Ordnance letter of requirements, dated 8 July 1911.<sup>384</sup>

Finally, because the 6-inch gun was one of the most numerous guns in the fleet a breakthrough in design could reward great benefits. In 1912 Beardmore, who to this point had avoided the gun business, submitted a 5.5-inch gun that they proposed as a replacement for the 6-inch gun. The shell weighted the same, being 5-calibres in length. It was rejected on the dubious grounds that it might not be as accurate, although it had more muzzle velocity than the 6-inch shell at 6,000 yards due to less drag.<sup>385</sup> This was a lost opportunity for the Ordnance Board and the navy, and could have had ramifications in the design of heavy guns for the army as well, such as the 60-pr, which was just being produced at the time. This insistence on maintaining 3-calibre shells as a basis of British design meant that they possibly had a prejudice that was not good for the long-term evolution of ordnance. The inability to consider new ballistic calculations

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<sup>383</sup> Ibid. 20.

<sup>384</sup> Ibid. 21.

<sup>385</sup> SUPP 6/167. Annual report of the president. 1912. 132-133.

such as shell calibre meant that ordnance could only evolve within certain constraints.

### **Fuzing**

As long-range guns became more of a possibility, fuzes also had to cope with the increased flight ranges and increased forces in firing. 1904 saw a great deal of research go into fuzing, which the committee saw as being the utmost importance, especially in long-range artillery using shrapnel shell.<sup>386</sup> Although outside this study, it should be noted that as gun technology evolved, it brought other technological advances with it, and producing fuzes that could fly longer distances and take the new energies of firing as well as being accurate was a challenge that had to be conquered before the new guns would be effective.

### **12-inch Guns**

One of the most important formulas in ordnance is Force equals Mass times Acceleration, or  $F = MA$ . We have known this since 1687 when Isaac Newton published his Second Law of Motion. British naval ordnance designers had realized the verge of what was technically possible with the

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<sup>386</sup> SUPP 6/63. Annual reports of the president. 1904. 3.

12-inch guns that had been the central armament of British battleships since the 1890s.

On the ocean going side of Whitehall, the Admiralty was dealing with technological changes as well, although they were slower moving than the Army. French, German, and American gun designers were experimenting with a replacement by the traditional, although restrictive, carbon steel gun with newer alloys that their armour plate producers had been working with, primarily nickel and chromium steel. New alloys, along with vigorous amounts of destructive testing, had given way to exponential increases in gun size, power, and accuracy. Both of these issues would come to dominate the recapitalization and outfitting of equipment.

The 12-inch Mark VIII was initiated in 1891, with firing trials in 1894, the IX in 1897 and 1899, and the X in 1903 and 1905.<sup>387</sup> In the 12-inch period, it took about 2–3 years from initiation to firing trials. After firing trials were held, gun designs that passed were ordered for production runs.

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<sup>387</sup> SUPP 6/164. Annual report of the president. 1909. 7.

## 12-inch Mark VIII

The 12-inch Mark VIII was the first battleship gun to be designed for the use of new cordite propellant. This made it important in the evolution of British arms, although by 1900 it was obsolescent.

There were 75 Mark VIII 12-in guns in total, assigned gun numbers 48-122 inclusive. These were broken down as: 49 Royal Gun Factory, 10 Elswick, 10 Whitworth, and 6 Vickers.<sup>388</sup>

The guns did not wear well. This was partly due to a feature of the state of manufacturing when they were designed and built. It became known with these tests that the 12-inch Mark VIII were often faulty because they were not properly hardened, with the water bath turning to steam before proper annealing occurred. These guns had the physical attributes of not being hardened at all.<sup>389</sup>

As the guns became obsolescent, several were rebuilt for experimentation. One of the Elswick made inner 'A' tubes for a 12-inch Mark VIII made in early 1906 was made to a previous RGF design, No 9988, instead of the then current 9988A. This gun was produced apparently at Elswick, but it was specifically slated for a spare tube for *Vengeance*. The change was in the design of the breech chamber, and

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<sup>388</sup> SUPP 6-67. Annual reports of the president. 1907. 21.

<sup>389</sup> SUPP 6/163. Annual report of the president. 1908. 19.



allowed for newer powder. 12 Mark VIII guns received the modified chamber, of which there were 3, numbers 50, 51, and 77, which were used for proofing size 45 MD after its introduction. Normal pattern Mark VIII guns could not be used for this purpose.<sup>390</sup>

One of the problems with the gun was that due to the barrel not being annealed, along with its use of Mark I Cordite, it wore excessively. One gun had been relined less than a year after mounting, from *Jupiter*. 64 rounds had been fired, and for some unascertainable reason the liner cracked. The investigation showed no cause.<sup>391</sup>

The Mark VIII was also the first British gun to show signs of choking. The guns elongated due to the friction of the shell pulling the barrel to a longer shape. The 12-inch Mark VIII, No 50 had fired 132 6/16 equivalent full rounds (178 total) and was still not in need of rifling, yet, it did have copper deposits as well as an apparent cannellured ring issue, but more was to be learned from this gun after it was rerifled. It was, along with No 54, a P&E (proof and evaluation) gun. The choking experiments seems to not have affected these particular guns as much as some examples in the field.<sup>392</sup> On the other hand, No 54, 12-inch Mark VIII was transferred to Proof work, and within 9 full rounds, had choked

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<sup>390</sup> SUPP 6/66. Annual reports of the president. 1906. 2.

<sup>391</sup> Ibid. 108.

<sup>392</sup> SUPP 6/67. Annual reports of the president. 1907. 1.

so badly it had to have the choke removed. This problem would continue in several classes of 12-inch gun as will be seen.

An interesting experiment showing the technology of the time was conducted on a gun in 1908. The firing time, or the time it took from the pushing of the trigger to the time the projectile left the bore, was not normally measured, but it was in the 12-inch Mark VIII, and it was roughly .1 seconds, of which .025 was the time it took for the shell to transit the bore, therefore ignition and burning took on average .075 seconds.<sup>393</sup>

### **12-inch Mark IX**

The Mark IX was the follow-on for the successful but obsolescent Mark VIII. The gun was 40 calibres long, which in this case meant 40 feet of rifling. 110 in total were built. 44 were made by the Royal Gun Factory, 36 by Vickers, and 30 by Elswick.

The gun proved to be an accurate gun at the time. A Director of Naval Ordnance minute of 19 October 1900 stated that guns had an acceptable error of 5 feet at 2000 yards for all guns. The committee came to the conclusion that there would be a difference in vertical and horizontal

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<sup>393</sup> SUPP 6/163. Annual report of the president. 1908. 88.

errors due to manufacturing technique as part of the industrial policy set forth.<sup>394</sup>

### **The Cracking Problem**

The gun was prone to cracking, although little was known why for the early part of the gun's life. Vickers-made guns were the only ones to crack or fail, five of their 36 being removed from service due to shortcomings in manufacturing.<sup>395</sup> All the Vickers cracked guns failed at the point of 72 to 84 inches from the muzzle, where the second wire cannellure was found.<sup>396</sup> An example was a Vickers manufactured Mark IX that split from 69 inches to 94 inches after 36 rounds had been fired. The gun was made in January 1901, although it was blamed in this case as a blatant manufacturing error<sup>397</sup>

Vickers gun No 130 in 1900 failed first inspection, and Vickers relined it. Vickers complained of difficulty of relining accurately such a large gun. This reinforced the need for Woolwich to undertake all relining. The gun was eventually tested at Shoeburyness, but Vickers was charged for 'reduction of life of rifling on account of rounds fired'<sup>398</sup>

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<sup>394</sup> SUPP 6/60. Annual reports of the president. 1901. 36.

<sup>395</sup> SUPP 6/67. Annual reports of the president. 1907. 21.

<sup>396</sup> Ibid. 24.

<sup>397</sup> SUPP 6/66. Annual reports of the president. 1906. 107.

<sup>398</sup> SUPP 6/60. Annual reports of the president. 1901. 34.

A product of the cracking of the Mark IX 12-inch guns was that the CSOF, Donaldson, believed that without a redesign, these would crack again after they were relined. The Director of Naval Ordnance also thought along these lines, and suggested putting tapered liners into guns that were slated for relining. As a note, those which had already received strengthened reliners could not be relined with a tapered tube. Therefore, all relined guns before 30 January 1912 were still stuck with outdated technology. The new tapered liner was to a Royal Gun Factory design.<sup>399</sup> Only three classes of pre-dreadnought ships received the Mark IX, and due to this, the gun saw little action.

The possible reason for later guns such as the Mark X and XI and the 13.5-inch guns being built without experimental models being constructed first experience with the 12-inch Mark IX. The experimental gun was delivered late, which caused delays in designing the breech, and led to delays in building guns for the new classes of vessels that they were to be mounted on, which would have been the *Formidable* class of battleships.<sup>400</sup> Indeed, 'No trial gun has been ordered, as the OC considered such procedure unnecessary, owing to general similarity of design to that of the 12-inch Mark IX'.<sup>401</sup> This policy was instituted in 1903

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<sup>399</sup>SUPP 6/167. 124.

<sup>400</sup>ADM 1/7761. D.N.O. Director of Naval Ordnance In-letters 1904 Nov.-Dec. 2.

<sup>401</sup>Ibid. 1.

by the Ordnance Committee and was seen as a ‘great advance’ by the DNO, Rear Admiral Angus Macleod, as it created the possibility of installing guns of the newest type when commissioning vessels.<sup>402</sup>

It also meant that designs simply copied previous design elements. It stopped major innovations or engineering changes in how the guns were made. At any other time in history this would have been acceptable, but the advances in propellant technology in the first decade of the century made for much more energetic propellants without updated guns that could fully utilize this advance.

In 1906, Gun 172 of the 12-inch Mark IX cracked its inner ‘A’ liner after only 36 5/16 equivalent charges. It was relined and repaired by the Royal Gun Factory.<sup>403</sup> This was an indication weaknesses that emerged later. By 1913, so many Mark IX 12-inch guns were being relined that it was not possible to get *Duncan* and *Albemarle* a combined five new guns, and it was suggested they be lapped out instead of being replaced for the time being, as they were being used for gunnery tenders.<sup>404</sup> Obviously Woolwich was working at capacity, or the secondary suppliers were at capacity.

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<sup>402</sup> Ibid.

<sup>403</sup> SUPP 6/67. Annual reports of the president. 1907. 2.

<sup>404</sup> SUPP 6/168. Annual report of the president. 1913. 111.

## The Scale of Problems

Of the 110 Mark IX guns built, 20 had cracked, 14 circumferentially, and six longitudinally. The average equivalent full rounds were 102 for a circumferential crack and 50 for a longitudinal crack. (There was a need for 76 mounted guns.)<sup>405</sup> The average life of these guns before achieving worn out status was 92 rounds with Mark I Cordite. With mixed charge Mark I and MD, it was 104.

Due to the amount the gun was studied, a drop in pressure from the 12-inch Mark IX guns of *Hindustan*, was revealed as ‘A 12-inch Mark IX gun, using MD cordite charges, would lose about 10 feet per second for every 14 rounds. That would be 40 yards at 6,000 yards.’<sup>406</sup>

The accountants calculated that each shot cost the Admiralty roughly £13.33. A gun was re-lined at Armstrongs due to faults in manufacture, the life of the rifling was shortened by 3 shots, which the Chief Inspector Woolwich believed was worth £40 over the life of the gun.<sup>407</sup>

In another case, an accepted gun, number 162 from Armstrongs, failed due to the breech bush split on first round, the gun then being

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<sup>405</sup> Ibid. 112.

<sup>406</sup> SUPP 6/163. Annual report of the president. 1908. 87.

<sup>407</sup> Ibid.

repaired by Armstrongs and accepted after being within 2.5 feet at 2000 yards, although the firm was fined £ 250 as a consequence.<sup>408</sup>

### 12-inch Mark X

The 12-inch Mark X gun was a 45-calibre gun designed for vessels at the heart of a historic change in shipbuilding. Although not specifically designed for her, the Mark X would be received by HMS *Dreadnought*. The gun had fewer years as the premier gun of the Royal Navy, but was mounted primarily on the first British Dreadnoughts as well as the world's first two classes of battlecruisers. It was at the experimental stage in 1903 as a 12-inch 45 calibre gun. The gun was designed specifically for Cordite MD, and the powder required a special chamber shape. The gun was designed by the Royal Gun Factory, under the watch of the Chief Inspector, Woolwich and Explosives Officer. Given that 18 tons was the maximum breech pressure, with eight tons maximum muzzle pressure. It was also explicitly stated that the design should have much in common with the Mark IX, to facilitate production.<sup>409</sup> The eventual design was for a gun 'designed' by Armstrongs and based upon the build parameters of the Mark X. The gun because of this did not have to incorporate a complete

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<sup>408</sup> Ibid. 36.

<sup>409</sup> SUPP 6/62. Annual reports of the president. 1903. 1.

trial gun, as there was little to trial. The order seems to have been placed for rifling and ballistics test guns alone.

The DNO stated in testing of new bands for the 12-inch Mark X gun that he would accept new bands of 'good accuracy with it could be relied upon for the first 60 rounds fired from a gun'<sup>410</sup> The testing at Shoeburyness showed that in test conditions, guns were still showing at 7,300 yards an error of 32 yards over seven rounds. This mainly came through a lateral deviation of 15.4 yards. This meant that the targets were on average missing their aiming points by 15 yards left or right. This was actually pretty accurate at a distance of over five miles.<sup>411</sup> The error was largely due to the service band 11606, which was chosen and cleared for 12-inch guns with Marks VIII, IX and X.

Although the gun had a higher velocity than the older Mark IX, the Mark X was a strategic failure. The full life of the 12-inch, Mark X was 150 rounds, according to the Ordnance Committee in September 1907<sup>412</sup> It was strategically important that HMS *Dreadnought* had 80 rounds per gun in its magazines, and hence could not have fired two full loads without being relined. The gun life was proven by Elswick gun number 292 which was rejected for active service but used to experiment. What mattered was

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<sup>410</sup> SUPP 6/66. Annual reports of the president. 1906. 6.

<sup>411</sup> Ibid. 7.

<sup>412</sup> SUPP 6/67. Annual reports of the president. 1907. 3.



the finding that the 12-inch Mark X guns were to have a lifespan of 175 rounds, with this gun showing that it would last 75% of its life, or 130 rounds.<sup>413</sup>

Of the 12-inch Mark X guns built in 1907-1908, nine had severe problems that were reported to the Ordnance Board. Of them, three each were from Armstrongs, Vickers, and the Royal Gun Factory. The Woolwich had one inner 'A' tube from Elswick, and two from Openshaw. Openshaw, an Armstrongs plant, also made the damaged tubes for the two Vickers models in 1908. Due to Vickers need to subcontract manufacture of components it demonstrates Vickers even by 1908 was unable to manufacture nickel steel to a quality necessary to put in their big guns.<sup>414</sup>

### **Mark X Testing Numbers**

Testing of the 12-inch Mark X guns had given some interesting figures. A proof round equalled two full service rounds. Also, the gun no 288 made by Elswick had fired 150 equivalent rounds, 3 proof, 144 full. It was stated that muzzle velocity had fallen from 2,762 to 2,679 f/s. The condemning feature for this gun was a measurement of wear 1 inch from commencement of rifling. In this case, the limit was 12.76 inches in total

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<sup>413</sup> SUPP 6/163. Annual report of the president. 1908. 3.

<sup>414</sup> Ibid. 6.

diameter, yet, this gun was still at 12.5 inches, or about 90 rounds short of condemnation.

With this calculation, and knowing in hindsight the opening salvo at Jutland in May 1916 was 14 kilometers, or 15,310 yards or 45,930 feet, total flight would have changed from 16.62 seconds in the new barrel, to 17.14 for the older barrels. Therefore, the worn barrels, would have missed the target by .52 seconds or 1,393 feet, almost a quarter mile. Of course, these are vacuum calculations and do not take into effect angle of fire, drag, or other calculations that would slow down the projectile as it travelled including shape or any other ballistic coefficient.<sup>415</sup> This gun was also from one of the first batches to use nickel steel.

What is very interesting is that ‘a 12-inch Mark X. projectile, fired at 8 degrees elevation, with a muzzle velocity of 2,710 feet per second, retaining that angle to the trajectory throughout its flight, would strike base first, at some 13,200 yards’. ‘In recent practice with this projectile, an officer posted at a range of about 14,400 yards was able to see the shell directly after first graze, and to follow it to its second graze at 16,500 yards. In most instances it was tangential to its trajectory.’<sup>416</sup> If this was indeed the case that projectiles were coming out of rifling was significant for many reasons, not least fuzing. Secondly, if a shell bounced between 3,300 and

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<sup>415</sup> Ibid. 2

<sup>416</sup> Ibid. 28.

2,100 yards there was also a significant amount of energy still in the projectile to create such a flight.

### **Increased 12-inch Life through Munitions Improvements**

In 1908, it was estimated that 12-inch guns, with new driving bands as introduced in 1900, had the life expectancy of 220 and 130 rounds with Mark I Cordite in Marks VIII and IX respectively. With MD, that was increased to 400 for the VIII, 240 with the IX, 200 for the X, and for the XI the data was inconclusive.<sup>417</sup>

There were issues of 12-inch Mark X guns expanding, with three used in Cordite tests expanding after just four shots. (1 E Co and 2 VSM). This caused all of *Dreadnought's* guns to be checked, and none of the ten were shown to have signs of expansion. The guns by this time, February 1909, had fired between 41 and 50 shots respectively. The Chief Inspector, Woolwich thought that this expansion might be caused by instability of the projectile when firing. The shells showed heavy grooving. This appeared to be proved in several cases. That being said, No 288 had fired 193 equivalent rounds.<sup>418</sup>

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<sup>417</sup> Ibid. 33.

<sup>418</sup> SUPP 6/164. Annual report of the president. 1909. 3.

## 12-inch Mark XI

On 21 June 1906 the Director of Naval Ordnance stated that a replacement more powerful than the 12-inch Mark X was likely needed soon. He wanted a muzzle velocity of 2,850 f/s and 50 calibres from a 12-inch gun.<sup>419</sup> It was to not exceed 18.5 tons chamber pressure, and 8 tons pressure at the muzzle. It was also to be nickel steel.<sup>420</sup> The requirements were difficult to comply with, as the energy required to achieve the desired velocity pushed the abilities of both 1906 physics and industrial capacity.

In the design phase, using guns 401 and 403, both Elswick and Vickers were having difficulties getting the nickel steel to be both elastic and hard enough to avoid expansion or cracking respectively. Pressures should have been lower than designed, and the metal itself was to blame. It appeared that the reason for the abandonment of the 12-inch class was not the end of the use of length: it was due to the inability of the manufacturers to produce a 12-inch gun in nickel steel that could comply with the design specifications. The elasticity simply was not there without either rebounding or cracking with the frightening new muzzle velocity energy on the limited diameter of the barrel.<sup>421</sup>

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<sup>419</sup> SUPP 6/66. Annual reports of the president. 1906. 8.

<sup>420</sup> Ibid. 9.

<sup>421</sup> SUPP 6/163. Annual report of the president. 1908. 9-10.

There was much discussion as to whether the new 12-inch gun was to be wired to the muzzle, or if it was to be made solid. This came out of the contemporary conviction that guns that were fully wired might be less accurate than those that were solid built. The belief was that the gun might be slightly bending during firing. This was tested in a 7.5-inch gun with inconclusive results, and no proof was shown either domestically or internationally that using wire would entail less accuracy. In addition, with the cracked tube of the first Vickers gun, it was decided to go back to a fully wired gun on the Mark XI gun.<sup>422</sup>

The majority of the design internally for the 12-inch Mark XI came from the lessons learned from the rebuilding of the Mark VIII. This would have meant that the CSOF (Donaldson) was essentially the inventor of the Mark XI 12-inch gun and Mark XI 6-inch gun. The Mark XI 12-inch guns appears to have been a creation that was produced quickly, and without a need for much research and development, and even rifling was accepted from the Mark X. It was an evolution in design, adding 5 feet of barrel.<sup>423</sup>

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<sup>422</sup> SUPP 6/164. Annual report of the president. 1909. 7.

<sup>423</sup> SUPP 6/67. Annual reports of the president. 1907. 5.

### Early Mark XI Orders

The gun was ordered by the DNO (Reginald Bacon) on 28 November 1908, apparently as a sole contract to Vickers with the requirement of having the same remaining velocity as the 12-inch Mark X at 8,000 yards. The very first 50-calibre 12-inch gun, No 401, 12-inch Mark XI was made by Vickers. After 38 equivalent rounds, it was found to be cracked for 157 inches from the muzzle. It was decided to continue using the gun in testing to gather data on what had happened with cracked barrels.<sup>424</sup>

The gun according to Dawson and others was cracked because the shell had been improperly handled, so they implied no responsibility whatsoever for the cracked barrel. They argued that the shell had gyrated in the barrel when fired. This suggestion was countered by the Ordnance Board on the grounds that the type of scoring used in the proof was not confirmation, as it had been evident many times before in other high velocity guns, and this result had never occurred before.<sup>425</sup> The Board concluded that Vickers had no justified reason for why their gun had failed. The Ordnance Board seems to have little time or patience for Dawson's excuses.

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<sup>424</sup> SUPP 6/163. Annual report of the president. 1908. 6.

<sup>425</sup> Ibid. 7.

A Vickers order for 12-inch Mark XI guns was suspended in order to put a thicker inner 'A' tube into the gun so that the choking issue would be negated.<sup>426</sup> It appeared to be a velocity issue, and not an energy issue, as the difference between energies was great: 280,000 ft pounds of energy vs 2,380,000 ft pounds of force. By the first year (1909), 18 of the Mark XI, and one Mark XII (RGF) had defects that were cited, yet all were eventually accepted. It appears that the main reason the Mark XI was rejected as a design was not the lack power, but that the gun was too difficult to manufacture with the current powder technology. With later research this could be different, but the powder to gunmaking technology was simply not there to make the 12-inch gun a viable service piece.<sup>427</sup>

Due to higher muzzle velocity the XI also was wearing out much quicker. The wear rate of a Mark XI would, with the new powder and shell designs last about 160 rounds.<sup>428</sup> On the 43- 12-inch Mark XI or XII guns proofed up to the end of Jan 1910, 22 had exceeded high limits by the end of 1910. This extreme wear in such a new gun was only occurring with these 50 calibre, 12-inch guns.<sup>429</sup>

As it became quickly obvious that there were critical failures in the 12-inch Mark XI, a new competition was hastily instituted. Coventry

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<sup>426</sup> SUPP 6/65. Annual reports of the president. 1905. 7.

<sup>427</sup> SUPP 6/164. Annual report of the president. 1909. 19-20.

<sup>428</sup> Ibid. 8.

<sup>429</sup> SUPP 6/165. Annual report of the president. 1910. 14.

submitted a design in the competition for a new 50-calibre 12-inch gun competition, although it appears to have been submitted after Vickers had already submitted plan 15,830, or service Mark XI. In the end, the requirements put on the Coventry design were so significant that it essentially made it a Mark XI. The Board went so far as to say ‘The Board noted that the CO Works design No 1,015 F was practically the 12-inch Mark XI design.’<sup>430</sup>

### **Final 12-inch Gun Reworks**

The first modification to the design, was to rework the wiring, with the hope of making the gun more rigid. ‘The original 12-inch Mark XI was not wire wound at the muzzle, and had to be strengthened when converted into Mark XII by wire winding, but this had to be done without altering the balance or the contour of the gun to any material extent. It was impossible to do this without resorting to unusually high wire tensions.’<sup>431</sup>

Coventry pointed out when building their first 12-inch Mark XI gun that Vickers had calculated incorrectly the shrinkage between the ‘A’ and ‘B’ tubes. When asked by CSOF, Vickers gave an answer of calculations that completely perplexed the CSOF. This caused delays until Vickers

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<sup>430</sup> SUPP 6/163. Annual report of the president. 1908. 8.

<sup>431</sup> SUPP 6/165. Annual report of the president. 1910. 33.



could undo their mistake. No charge seems to have been incurred for this work.<sup>432</sup>

The Director of Naval Ordnance requested a new competition after the failure of the XI and the XII guns. This had all the players submit, Woolwich, Beardmore, Elswick, Vickers, and Coventry. All had slight differences in the size and shape of chambers. The test trials of one per manufacturer of 12-inch 50 calibre guns proceeded to commence, with each manufacturer picking their own bands and powder. Beardmore picked MDT, Vickers wanted 55 MD, then Chilworth, or MDT, settling finally on MDT, and Elswick chose size 45 MD after their request to use Chilworth Special was declined.<sup>433</sup> All seem to have been unable to really get anything more out of a 12-inch 50 calibre gun. Beardmore seems to have really come up with an independent breech. The 12-inch 50 calibre experimental tests were formally cancelled on 30 May 1911, with the exception of the MDT tests that were being conducted on the Coventry gun.<sup>434</sup>

The failures of both the Mark XI and the Mark XII forced designers to conclude that the era of British 12-inch guns was at an end.

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<sup>432</sup> SUPP 6/164. Annual report of the president. 1909. 14.

<sup>433</sup> Ibid. 31.

<sup>434</sup> SUPP 6/166. Annual report of the president. 1911. 8.

The effectively build guns, the size of the shell would have to increase, and therefore the size of ships as a whole.

### **12-inch Mark XIII**

The very last 12-inch guns designed and accepted were not destined to ever grace a British warship. *Agincourt* was outfitted with 12-inch Mark XIII, which were 12-inch 45 calibre guns designed for export by Armstrongs. Originally ordered for the Brazilian Armada, the vessel was sold to the Ottoman Empire in 1913, and seized at the outbreak of the war by the British government. The guns were apparently made of nickel-chrome steel, which Elswick thought led to one cracking at proof.<sup>435</sup> *Agincourt's* guns could not be traded for those of any other British ship, making it a difficult vessel to use, as it would be almost impossible in wartime to replace the barrels.

### **Cannelured Rings / Choking**

The 12-inch guns dominated British battleships from the 1890s until the commissioning of the *Orion* Class in 1912. In under a generation, British industry produced four separate gun designs of 12-inch bore, each increasing in length or calibre.

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<sup>435</sup> SUPP 6/169. Annual report of the president. 1914. 255-256.

Mark I Cordite had a property of compression within the barrel. The compression created an elongation of the barrel, paired with the construction technique of having mounting points on the inner 'A' tube that caused the material to only travel so far before bunching up. This had two negative effects. First, it meant that some areas were increasing in bore size and therefore the gas check was being lost. Second, the material had to go somewhere, and it tended to catch where the shoulder rings were located. This meant that guns were choking at areas near the shoulders of tubes when wearing, and these chokes were possibly caused by the tubes moving. Especially the liners or 'A' rings and the outer jackets were moving as the gun wore.<sup>436</sup> This was made even worse by coppering deposits on the copper obturator bands. With the introduction of Cordite MD, this phenomenon had 'ceased to be important'<sup>437</sup>

The problem was apparent on the Mark IX and Mark X 12-inch guns as well as the Mark X 9.2-inch guns. In 1905, all new Mark X 9.2-inch guns were to be relined with a new design from the Royal Gun Factory for liners, with Vickers designed cannellured rings.<sup>438</sup>

In 1906 the Committee recommended, 'That as the elucidation of the question of splitting of inner A tubes and similar problems requires a

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<sup>436</sup> SUPP 6/65. Annual reports of the president. 1905. 5.

<sup>437</sup> ADM 186/220. Manual of Gunnery for HM Fleet. 115.

<sup>438</sup> SUPP 6/65. Annual reports of the president. 1905. 41.

research department, with the services of an expert trained in a physical laboratory, and familiar with the mathematical investigation of elastic problems, such a department should be formed without delay. If such a department had existed in the past the tendency of certain guns to stretch and choke would probably have been detected as an early stage, and much subsequent annoyance have been obviated.<sup>439</sup>

After 1907 and into 1908, the use of cannellured rings to strengthen the transition between Inner and ‘A’ tubes started to transition to tapered tubes, which were harder to make and reline, but seemed to not cause the problems that had been the weakness of the Vickers design. This new design was created by CSOF (Hay Frederick Donaldson) and was approved by the Board in December 1908 for use on the 6-inch Mark XI.<sup>440</sup> As part of this, Donaldson created a machine that could be carried onboard to rerifle the guns in situ. One problem though, was as guns were fired, the barrel cycled through hot and cold sessions, and essentially annealed the barrel to a much harder steel, which might make the new machine unable to cut into a much harder steel.<sup>441</sup>

The choking of barrels was discovered in tests in April 1908 to have been caused by displacing the shoulder of the ‘A’ tube. The two shoulders

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<sup>439</sup> SUPP 6/66. Annual reports of the president. 1906. 93.

<sup>440</sup> SUPP 6/163. Annual report of the president. 1908. 12.

<sup>441</sup> SUPP 6/65. Annual reports of the president. 1905. 5.

became disconnected and then the inner tube apparently stretched.

Donaldson also stated that the new cannellured rings were not a cure, but a ‘temporary palliative for the defect.’ The Superintendent, Royal Gun Factory, commented that at the choke the molecular structure had not changed, and therefore it had occurred down the length of the barrel. He believed the steps were ‘a defect in design and the gun would be better without them’.<sup>442</sup>

In 1909 the theory was put to the full test. Gun No 50, a Firth built carbon inner ‘A’ tube 12-inch Mark VIII that had been used in projectile proof, was sent back for relining. It had fired an equivalent of 268 13/16 rounds with only slight indication of choking.<sup>443</sup> This was the first gun to fire a great deal of rounds after the introduction of cannellured rings. It was commented that this particular tube was much harder than its predecessors. This was not recommended for further use.<sup>444</sup>

### **The 13.5-inch Mark V Gun**

The 13.5-inch BL Mark V gun that took the Royal Navy into the super dreadnought age was one of the most secretive projects conducted in the *Dreadnought* era. The gun was designed with the hope that the

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<sup>442</sup> SUPP 6/163. Annual report of the president. 1908. 1.

<sup>443</sup> SUPP 6/67. Annual reports of the president. 1907.

<sup>444</sup> SUPP 6/164. Annual report of the president. 1909. 1.

Germans would not figure out that the new ships would be carrying 13.5-inch guns instead of 12-inch guns. The new *Orion* Class was to begin a new era of British naval superiority, and make older Dreadnoughts obsolescent. The gun was requested in October 1908 as a 12-inch Design A\*, and approved in December 1908, with the gun design being given to Vickers in February 1909, a full three years before the ships were to be launched.<sup>445</sup> The gun came about from a meeting between the Director of Naval Ordnance and Lt Dawson of Vickers on 20 October 1908, when Dawson proposed the idea of a new gun that could be 13, 13.5, or 14-inches in calibre. Vickers submitted a design on 3 December 1908, of a 13.5-inch 45 calibre. The real benefit of this new gun, though was that the wear rate was much less than that of any of the previous 12-inch guns. The secrecy was to be taken so far as to even send all correspondence in double enveloped letters marked secret.<sup>446</sup>

From the perspective of manufacturing, this was the first capital gun could be manufactured by any firm that was willing and able, instead of just Vickers and Armstrongs.<sup>447</sup> This was due to the way in which patents were controlled, and that essentially all of the design came from the Royal Gun Factory. The great expansion of technology as well as the political

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<sup>445</sup> ADM 1/8064. D.N.O. Director of Naval Ordnance In-letters 1909 Jan.-June.

<sup>446</sup> Ibid.

<sup>447</sup> Ibid.

requirements of a larger fleet after 1908 called for a gun larger than the 12-inch naval guns. 13.5 and 15-inch guns would take on this role in time.

The navy had essentially already exceeded with its current gun the capacities of the calibre. As the 12-inch Mark XII was 50 calibres already, any added weight through lengthening the barrel would have been extremely problematic for turret and gun balance. Only a few people, primarily the President of the Ordnance Board and Reginald Bacon as DNO, were to know that the new classes of vessels were to carry the larger guns. Importantly, Bacon requested up front designs that would be available for general production, and not exclusive to Vickers. The first physical evidence of the 13.5-inch is mentioned in an Admiralty file from the DNO to Vickers on 22 February 1909 requesting a new drawing.<sup>448</sup> Vickers received an order for an experimental tube to be produced on 25 February 1909 to design #19788G at a cost of £11,400 and delivered to Woolwich, and with a mechanism for £1,250. Delivery was to be nine months after the order, or roughly 25 November 1909. It was important to proof and test the gun before 31 March so that funds for that fiscal year could be used for the new guns, instead of having to wait another year for funding. The Admiralty specifically requested the gun's forgings be made of nickel steel, a realization that carbon steel had no purpose on the most

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<sup>448</sup> Ibid.

modern designs. It is unknown if Vickers actually created the nickel steel for the prototype, or if it was subcontracted. Vickers subsequently submitted a drawing dated June 17, 1909, a full three years before it was finally mounted on a ship, and a full year before a vessel that it was supposed to arm was laid down.<sup>449</sup> In regards to the 15-inch gun the dates of the 13.5 are important in understanding the relationship between ship and armament design as well as ship and armament building schedules.

It can be surmised from the experience of the 13.5-inch gun that it took industry roughly one year from the release of a requirement to the delivery of the first experimental model. It would have then taken at least six months for tests to be undertaken at Woolwich and Shoeburyness to ascertain the ballistic data needed to make a decision for orders, and another nine months for a gun to be delivered to Woolwich from the time of the order, and another month of proofing and inspection before it could be issued to a vessel.

It was calculated that the 4-calibre radius could penetrate 12-inches of KC armour at 9,300 yards, whereas the 6-calibre could penetrate the same at 11,500 yards, but the 4-calibre proved much more accurate at 12,000 yards. In addition, the gun appeared to wear less than every

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<sup>449</sup> Plans and Photographs Department, National Maritime Museum, Woolwich UK. drawing 15089.P.



modern 12-inch gun save the old Mark VIII. The life expectancy of these guns was estimated at 450 rounds.<sup>450</sup> That in one swift design proved the theory of gas speed is a major factor in the wear of a gun. The longer barrel wear was directly attributed to the heavier but slower projectile that had the same force at distance, although had a much lower muzzle velocity.

The procurement of Reginald Bacon as director of Coventry Ordnance Works certainly seemed a suspicious situation in light of the orders for the 13.5-inch guns. Coventry asked for the drawings for the 13.5 in July 1910, as a likely prelude to bidding on the contract.<sup>451</sup> The firm was desperate to get a large gun contract, and Bacon was the most well informed individual in the Government. This ‘revolving door’ of officers to the trade was actually very rare. The only previous experience of such a transition was when Trevor Dawson was poached by Vickers in the 1890s.<sup>452</sup>

The first delivery was made by Vickers in November 1909. Range and accuracy tests were carried out on 16 April 1910.<sup>453</sup> This meant that from concept to proof, the gun took just over 18 months.

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<sup>450</sup> SUPP 6/165. Annual report of the president. 1910. 2.

<sup>451</sup> ADM 1/8064. D.N.O. Director of Naval Ordnance In-letters 1909 Jan.-June.

<sup>452</sup> Trevor Dawson Obituary. *The Times*, 20 May 1931.

<sup>453</sup> SUPP 6/165. Annual report of the president. 1910. 1.

### Previous 13.5-inch Guns

The Mark V was not the first Royal Navy gun to utilize the 13.5-inch size. It had been the mainstay in the 1880s and 1890s battleships before the introduction of Cordite and the 12-inch Mark VIII. The original 13.5-inch Mark I-IV gun fired a 1,250 pound shell, although the Mark V used a 1,400 pound shell. The initial design also called for this lighter shell, although it was changed in the design process to a heavier shell, which gave lower initial muzzle velocity, but more power at a distance as well as lower barrel wear.<sup>454</sup> After initial tests proved very satisfactory, the well wearing Mark V allowed the Director of Naval Ordnance to try to get the gun to fire at a higher velocity, and higher accuracy, although the tests were not completely successful, leading to the introduction of the 15-inch Mark I.<sup>455</sup>

The first guns were noted for a problem of bend or droop in them. Both Elswick and Vickers were criticized for this.<sup>456</sup> Although this problem did not last, it was never truly known what caused it, although it did cause guns to be assigned as a left or right breech at proof and they remained that way throughout their lives, unless they were proofed again.

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<sup>454</sup> SUPP 6/167. 121.

<sup>455</sup> SUPP 6/165. Annual report of the president. 1910. 5.

<sup>456</sup> SUPP 6/167. Annual report of the president. 1912. 122.

### Rifling Tests With 13.5-inch guns

The Director of Naval Ordnance was the pushing factor in a set of experiments in uniform twist versus increased twist, and in a letter to the board on 13 October 1910 he stated that this was an urgent decision as it might delay the delivery of 13.5-inch guns on order<sup>457</sup> As technology matured, there was less flexibility in experiments over the entire fleet, and rifling was one of the topics that less work was done on. Experiments were conducted for rifling on the new guns with the 9.2-inch Mark X. The gun pattern was resealed with a uniform twist instead of the then present service increasing twist. This was due to accuracy issues. It was discovered that increasing twist in high velocity guns was not as accurate as uniform twist.<sup>458</sup> This discovery led to all British heavy guns to be designed with constant twist rifling by 1914.

### Producers of the 13.5s

For the first time, Beardmore was allotted a gun order with the 13.5-inch guns. Beardmore suggested a new system of manufacture due to their perceived difficulties in building up a 13.5-inch gun with its heavy and extensive forgings. They wanted to reproduce the traditional 'A' tube system with one that was more based on hoops. This new design did not

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<sup>457</sup> SUPP 6/165. Annual report of the president. 1910. 68.

<sup>458</sup> Ibid. 47.

appear to be a full wire wound gun.<sup>459</sup> The Ordnance Board interestingly did not reject this design outright, and let Beardmore experiment with the new technique in their production guns.

The Ordnance Factories also produced the new guns. Darlington Forge produced the inner ‘A’ tube forgings for the Royal Gun Factory to build up the 13.5-inch gun, and Brown and Cammell produced the ‘A’ tubes. Elswick was also producing inner ‘A’ tubes, along with Vickers.<sup>460</sup>

Armstrongs also utilized their Openshaw facilities which produced the 13.5-inch gun in 1913. It is not apparent if the tubes were also produced at Openshaw, or if they were simply building up the gun with tubes manufactured at Elswick and transferred.<sup>461</sup>

### **15-inch Mark I Gun**

Just as the 13.5-inch guns were designed to outclass older 12-inch guns, the 15-inch guns were meant to mount on the largest warships afloat, the *Queen Elizabeth* Class. The 15-inch gun appeared to have come out of nowhere in 1913. Elswick was tasked to build up a gun, which fired test shells by 5 September 1913. Vickers had also submitted a gun. The Vickers gun had irregular rifling and it was thought it would wear unevenly.

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<sup>459</sup> SUPP 6/166. Annual report of the president. 1911. 2.

<sup>460</sup> SUPP 6/167. Annual report of the president. 1912. 542.

<sup>461</sup> SUPP 6/168. Annual report of the president. 1913. 125.

<sup>462</sup> This would have been well after the *Queen Elizabeth* Class were laid down, 21 October 1912, and about the time they were launched, 16 October 1913, for the *Queen Elizabeth* herself.

Although the gun was essentially an oversized version of the 13.5-inch Mark Vs it superseded, it was not without problems. A meeting on 31 July 1914 showed that the most pressing matter at the Ordnance Board was a Vickers built 15-inch gun that had been made larger in the barrel due to a tool breaking. This gun would not be proofed until 9 November 1914.<sup>463</sup> It is significant that, as the world was about to be engulfed in war, the technical heads at Whitehall were worried about toolmarks. It showed that the failure of manufacturing had the ability to greatly affect the readiness of the Royal Navy. It also showed that seemingly small errors could have delayed, and possibly robbed Britain of its newest warship in the decisive battle.

As was normal with all new guns, experiments on the pressures involved in a 15-inch gun were conducted in January 1914. It should be noted that the results not forwarded to the Ordnance Board until July 31 1914. The experiment used a 1,920 pound projectile in a 15-inch Mark I. The temperature of the powder was 80 degrees Fahrenheit, with MD size 45. Round 1 used 390 pounds of powder with a velocity of 2,405 feet per

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<sup>462</sup> Ibid. 109.

<sup>463</sup> SUPP 6/169. Annual report of the president. 1914. 251.

second at 19.3 tons, whereas round 3 used 448 pounds of powder, with a muzzle velocity of 2,621, at 25 tons pressure.<sup>464</sup> This is significant as it showed that by 1914 the testing of overproof was well in force. 25 tons was well in excess of 18 tons working pressure, and even in excess of the experimental work done almost a decade before. In comparison, the 13.5-inch Mark Vs were to be proofed at 20 tons.<sup>465</sup> The decision to lower working pressure seemed to have been proven as a wise decision by looking at the results of the test. The increased pressure, which would have probably shortened the life of the gun by half, only increased the velocity of the gun by roughly 200 feet per second in a new gun. This difference would have diminished as the gun wore.

### 9.2-inch guns

The 9.2-inch guns were the mainstay of British naval ships below battleship grade as well as being the primary armament of coastal defences. These guns evolved within this context. They were not nearly as powerful as heavy main guns, but they did not have to be, and being much lighter overall, were able to be used on a wide variety of platforms. The evolutions of the 9.2-inch guns were the evolution of guns in microcosm.

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<sup>464</sup> Ibid.

<sup>465</sup> SUPP 6/166. Annual report of the president. 1911. 1.

The Director of Naval Ordnance asked on 21 October 1902 for two new designs, a 50 calibre version of both the 7.5-inch and a 9.2-inch gun. Requests were sent out to the trade to make the most powerful 50-calibre guns without exceeding 50 calibres, and not exceeding 20 tons pressure with Cordite MD.<sup>466</sup> As the smallest 'main gun' issued to large navy ships, the 9.2 was often considered an experimental platform with large returns, without large costs. This experiments was part of that case. The submitted 9.2-inch guns were marginal at best. Vickers submitted a design that did not meet the specification for travel of the projectile length.<sup>467</sup> Eventually, the Elswick design was chosen as the best for purpose, and they were asked to make the final proof gun.<sup>468</sup>

The design boffins at the Royal Gun Factory had taken the old designs for 50 calibre 9.2-inch guns and tweaked them so that they were either massively strengthened and stiffened, or easier to build. The latter was done through Royal Gun Factory design No 11,220 according to which the wire was wound on a tapered 'A' tube which made the need for complicated fastening wire rings unnecessary.<sup>469</sup>

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<sup>466</sup> SUPP 6/61. Annual reports of the president. 1902. Appendix 14.

<sup>467</sup> SUPP 6/62. Annual reports of the president. 1903. 9.

<sup>468</sup> Ibid. 12.

<sup>469</sup> SUPP 6/65. Annual reports of the president. 1905. 35.

Cordite also shortened these guns to a very short life. The life of a Mark X 9.2-inch gun was 125 rounds.<sup>470</sup> Manufacturing defects that caused cracking could shorten that to 74, as with gun 275. In addition, 9.2-inch Mark X guns had a problem of drooping, and a 13 August 1906 report from GOC Portsmouth showed that every gun under his command in the Portsmouth defences had had a droop appear, all 20 guns. Also as with the larger guns, 9.2-inch guns also had problems with artificially excessive wear. Two Portsmouth coastal defence based 9.2-inch Mark X guns had been found to be choked after 30 rounds. The Chief Superintendent, Ordnance Factories offered three solutions: One, borrow the lapping machine from the Navy, which would require finding 65 volts in a land establishment (a difficulty); two, make a land service machine; or three, dismount and send the guns to Woolwich.<sup>471</sup>

### 1908 Tests

All 9.2-inch Mark X guns were inspected in 1908, with a report being made to the Ordnance Board on 28 April 1908. Of 233 guns inspected, eight had been relined, four due to wear, two in flaws, and two in cracks. The guns varied in life from nine rounds to 213, but most had fired less than 40. 'The wire tensions were extremely ambiguous; no

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<sup>470</sup> Ibid. 39.

<sup>471</sup> SUPP 6/67. Annual reports of the president. 1907. 8.



drawing appeared to have existed to govern this operation. Each maker had worked on individual theories which were unrecorded.<sup>472</sup>

The guns that had choked failed at the second ring, although rarely at the first or third, unless the second had already failed. Elswick after reading the report commented that they believed a thicker inner ‘A’ tube was required to fix the situation.<sup>473</sup>

Even when guns did fire in their prime, a 9.2-inch Mark X gun had a mean error of 60.5 yards at 8,200 yards.<sup>474</sup> Although much better than the 12-inch guns, any cruiser engaged at what was seemingly full range could easily overshoot the target. This demonstrated that even the most controlled experiments contained a large amount of error that could affect the effectiveness of a fleet simply by chance.

### **Experimental 10s**

The 10-inch guns were seen as the natural follow-on to the 9.2-inch guns that had reached the end of their development life by 1905. On 13 November 1901 the Director of Naval Ordnance asked for a new design for 10-inch guns to be authorized, ‘and asked for suggestions as to

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<sup>472</sup> SUPP 6/163. Annual report of the president. 1908. 15.

<sup>473</sup> Ibid. 15-16.

<sup>474</sup> SUPP 6/164. Annual report of the president. 1909. 53.

the details that should be laid down to govern construction.’ The gun was designed to compete with the new American designs and mounted twin turrets on armoured cruisers. The Director of Naval Ordnance believed that the 10-inch guns could, if it be made light enough, replace the 9.2-inch as the general purpose weapon. The goal was to achieve 3000 feet per second in muzzle velocity. The gun was also to be designed to take the follow-on propellant to cordite, which had yet to be created. The committee believed that to satisfy the Key Performance Parameters the gun would either have to have an increase in muzzle and breech pressure, or an increase in calibre to achieve the stated goals with the current Cordite charge.<sup>475</sup>

The Chief Superintendent, Ordnance Factories, submitted a plan for a new and more powerful 10-inch gun, stating that it was currently impossible to produce to the original specification of 3,000 feet per second muzzle velocity as well as moderate weight and 500-pound projectile. He stated that he could get the gun up to 2,800 feet per second with the use of 18 tons per square inch. This could be achieved with 145 pound of Cordite. The Ordnance Factories proof officer calculated that to achieve the desired velocity, the gun would have to weigh 47 tons, 15 cwt, 1 qrs. and use 238 pounds of Cordite, compared to 31 tons and 2,800 feet per

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<sup>475</sup> SUPP 6/60. Annual reports of the president. 1901. 36.

second with 142 pounds Cordite as proposed. Armstrongs was requested to build a gun to a medium specification between the two extremes of weight and pressure<sup>476</sup>

As part of the research and design phase, the obsolete battleship *Revenge* was given 10-inch sleeves for her 13.5-inch Mark III guns. These were for range table practice. This would make a 30 calibre gun into a 40.5 calibre gun theoretically.<sup>477</sup>

A 'New and More Powerful 10-inch BL Gun' was designed as a replacement to the venerable 9.2-inch guns of cruisers. This increase in size would allow a 500-pound projectile, replacing the 380 pound projectile of the 9.2. The gun, proposed by Elswick, would be able to more efficiently deliver projectiles than the previous gun, without having the weight of the 12-inch battleship guns. The gun itself was too heavy as a true replacement, and as the Chief Inspector Woolwich did not see enough of an improvement over current guns, he decided to retire the design without a physical copy being made. This caused a redesign to the older 9.2-inch guns to create the 9.2-inch 50 calibre gun.<sup>478</sup>

In an unusual case, in December 1906 the sealed drawings for the Elswick designed 10-inch Mark V 50 calibre gun were unsealed as the gun

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<sup>476</sup> SUPP 6/61. Annual reports of the president. 1902. Appendix 4-6.

<sup>477</sup> SUPP 6/164. Annual report of the president. 1909. 1.

<sup>478</sup> SUPP 6/62. Annual reports of the president. 1903. 5-7.

had never been ordered since being sealed in 1903, and that it did not incorporate the new technology. This is interesting because it shows that in just three years guns became obsolescent, a huge demonstration of how fast technology moved. This gun had been intended to be first used for a refit of HMS *Renown*, which was built in 1895. The ever-increasing speeds of fleets meant that this ship was simply too obsolete to economically rebuild, as the Admiralty had moved away from the concepts of rebuilding ships, and started building ships new. This cost this particular design its only known possible mounting.<sup>479</sup> The concept of the armoured cruiser, along with the 10-inch gun had died with the invention of the battlecruiser.

### The 7.5-inch guns

The 7.5-inch gun was the primary secondary armament on British capital ships in the period under study. They were much more powerful than the 6-inch guns that were discussed earlier, and were used primarily in cases where the increased weight over the 6-inch guns was not a priority.

The very first 7.5-inch gun came with the 1901 approval of Vickers design number 1,388 G, accepted as the 7.5-inch Mark I gun. The Director of Naval Ordnance requested no delay in producing the gun by waiting for proof and trials. It was approved of the Vickers plan with

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<sup>479</sup> ADM 1/7761. 1904 D.N.O. Director of Naval Ordnance In-letters 1904. 1.

approved modifications. The rifling plan was delayed until after trials, but everything else was drawn up. It would take another seven months for the gun to be trialled and the final specification to be produced for rifling. In the end, it took almost 12 months from the time the gun had been first delivered in a drawing sufficient for tooling until the gun was proofed.<sup>480</sup>

The 7.5-inch Mark I had poor accuracy. It was discovered that the cause of this was the driving bands on shells. The copper band was removed and a cupronickel band replaced it. This made the gun much more accurate.<sup>481</sup>

Vickers and Armstrongs were asked to make a 50-calibre version based upon the design of the 45-calibre accepted design. This design was, like most 50-calibre wire wound designs, not acceptable operationally. The 50 calibre gun outperformed the 45-calibre gun with muzzle velocities of 3,090 feet per second versus 2,902. The increase in velocity for the weight penalty of another 5 calibres in length was not seen as worth the trade-off. The final program cancellation came when the gun was declared unserviceable due to 'serious cracks'<sup>482</sup>

The 7.5-inch Mark I was weak at the muzzle, so it was given a stronger jacket at the breech to remedy this. This was also incorporated

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<sup>480</sup> SUPP 6/60. Annual reports of the president. 1901. 42-44.

<sup>481</sup> SUPP 6/63. Annual reports of the president. 1904. 14.

<sup>482</sup> SUPP 6/61. Annual reports of the president. 1902. Appendix 18-19.

into the Mark II, a 50 calibre version that improved upon the previous attempt<sup>483</sup>

The 7.5-inch Mark II gun demonstrated an inherent weakness that many in the industry did not want to discuss. 'While all English guns, whether made in the OF, Elswick, or by the VM Co, are constructed on precisely the same principles, the EO Co prefer, when left free to do so, to shrink the outer over the inner 'A' tube, at the same time using much thicker outer tubes, especially at the breech end, than are the tubes used in the Government design'.<sup>484</sup> This had a direct effect on accuracy, which appears to be a reason why Elswick guns seem, inherently, to have been more accurate than the others, as the shell had less chance of movement within the barrel at unsupported parts. This principle was also put to the test with the army's long range heavy field piece, the 60-pr.

The 7.5-inch gun became the centre of a challenge to the traditional wire wound British design by the middle of the first decade of the century. There was a belief within industry and the services that high velocity guns that were fully wired to the end were less accurate. This was believed to be due to the rigidity of the wire to the barrel. The tests for new wiring designs for heavy guns requested in 1904 came back in March 1906. The results of tests conducted on the 7.5-inch gun that was not fully wired were not

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<sup>483</sup> SUPP 6/63. Annual reports of the president. 1904. 17.

<sup>484</sup> Ibid. 95.

conclusive enough to justify redesigning the 9.2-inch and 12-inch guns.<sup>485</sup> Oddly, the argument for full, wire wound guns occurred when a 7.5-inch gun that had developed a twist in 1905 had fired subsequently two proof, 148 full, 59 three-quarter, and 26 half charges, without developing any more twist, and without impairing the accuracy of the barrel.<sup>486</sup> This meant that the problem with the Vickers step issues at least in the 7.5-inch guns was not greatly affecting the overall life of the tube, which did not require immediate relining. It also in some regards proved the purpose of wire wound guns.

Nonetheless, problems with the new 7.5-inch guns were appearing in service. HMS *Carnarvon* had been completed in 1905, yet by 1906 her 7.5-inch guns had started to droop. CNC Malta stated the gun was bent 2.5 minutes down and 2.5 minutes right in 41  $\frac{3}{4}$  shots.<sup>487</sup> This excessive distortion was part of a trend in the new high velocity guns, which after firing just a few shots started to droop. The remedy was never stated, although a similar issue with the 18-prs was fixed by redesigning the guide rods in the carriage to increase the support.

*Swiftsure*, commissioned in 1903, had two nickel steel made 7.5-inch Mark I guns on board when commissioned. These were probably the

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<sup>485</sup> SUPP 6/66. Annual reports of the president. 1906. 16.

<sup>486</sup> Ibid. 23.

<sup>487</sup> Ibid.

experimental nickel steel guns ordered as the first British order of nickel guns. The guns by August 1908 had fired 58 and 63 rounds respectively. The guns showed good wear, and ‘the wear was certainly not greater than that which would be expected with carbon steel’. The guns were made of 3 per cent nickel, or the old S/20 specification also used on the original Mark I 18-prs.<sup>488</sup>

The 7.5-inch guns were, due to their high muzzle velocity, regularly tested. 67 7.5-inch Marks I and II, were examined after one split its inner ‘A’ tube. Two had fired 280 rounds, but most had fired under 40. Of the guns made to May 1908, Vickers was the only company that had problems with cracked guns under their manufacture.<sup>489</sup> In this time period this probably had more to do with their insistence on not using nickel steel whilst all other manufacturers had transferred to the new material as discussed in chapter five

### **14-inch Mark I**

HMS *Canada* was the only ship in the British battlefleet that had 14-inch guns. This was due to the vessel being built by Armstrongs for the Chilean Navy as *Almirante Latorre*. The 14-inch gun was designed to fire

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<sup>488</sup> SUPP 6/163. Annual report of the president. 1908. 12.

<sup>489</sup> Ibid. 16.



a 1,586 pound projectile. The vessel was purchased after the outbreak of hostilities, although before the war, several comments were passed to the Ordnance Board on her construction. *Canada* and her 14-inch guns were to have an experiment conducted as called for on 17 November 1914, although *Canada* had still not completed outfit. Her guns were not proofed until 16 December 1914, showing the lack of knowledge with this calibre.<sup>490</sup>

### Conclusion

The evolution and development of individual gun Marks for heavy artillery demonstrate why certain paths were chosen. The ability of seemingly small problems forced designs through the entire period. Also, this chapter demonstrates the quick evolution, especially for main armament of the Royal Navy battle fleet. Issues with cordite, barrel life, manufacturing, and the simple nature of the environment in which they would be used drove design in a way that is often difficult to understand. The next chapter will follow on with this theme but with smaller field based artillery.

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<sup>490</sup> SUPP 6/169. Annual report of the president. 1914. 253-254.

## **CHAPTER EIGHT: THE ARMY SUPPLY CHAIN**

### **Introduction**

The Army had very different issues with the supply chain. In general the Army bought more numerous and smaller pieces compared to its naval counterpart. This characteristic, along with the army's possible need in war, for much greater mobilization, had the effect of commanding industrial policy through their orders for an extent that some might consider disproportionate to their vote power.

The army entered the 20<sup>th</sup> century with the quickfiring 15-pr Mark I as the primary field gun of the Royal Artillery. A great number of experiments were conducted on it before deciding in 1902 for a new competition.<sup>491</sup> This competition eventually arrived at the 13-pr and the 18-pr for the Royal Horse and Field Artillery respectively as discussed in detail in Chapter Four. Many experiments were conducted before then, however. In 1901 the committee worked with new 4-inch breechloading guns, to test cased shot or separate shot. This experiment created the mindset that the uncased shell, i.e., powder not encased in a brass, was always the best. In this competition, the Vickers design failed, and Armstrong's was accepted, with a redesigned 'A' tube.<sup>492</sup>

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<sup>491</sup> SUPP 6/60. Annual reports of the president. 1901. 180-186.

<sup>492</sup> Ibid. 2.

Many of the post-award problems that caused the introduction of the 18-pr Mark II occurred from 1906 onwards. The measurement of all 13 and 18-pr guns after the 1907 summer exercises showed all guns within the range of acceptability. This was after a summer of gun failures as mentioned in Chapter Three. A redesign of the 18-pr was called for soon after deliveries of the Mark I occurred. This new Mark II 18-pr gun was a direct product of tubes bending in the first year of use. The first order for the new guns occurred in November 1909 with the Canadian order for 18-prs to outfit the Canadian forces.<sup>493</sup>

### **The 4.5-inch Howitzer**

The new Experimental Field Howitzer project was commissioned in 1901. The howitzer was defined originally to be used up to 7,000 yards. British engineers were fascinated with the 4.7-inch (120-mm) Boer howitzer with its 34-pound shell that was captured in South Africa. It was made by Krupp and outclassed much of what the Britain could field, and with a 34-pound shell only.<sup>494</sup> It was with this motivation that the temporary Howitzer Committee took up their work.

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<sup>493</sup> WO 395/3. Annual Reports 1909-1914. 1909. 72.

<sup>494</sup> SUPP 6/61. Annual reports of the president. 1902.53.

In general, the committee studied increases in range more than increases in power. The 5-inch howitzer was worked on from 1900 to 1902 to increase its range. This was done by lowering the weight of projectile from 50 to 40 pounds, which gave an increase in range of 1,200 yards. This increase still only gave accurate delivery to 6,000 yards. With the failure to meet the technical parameters, the program was cancelled.

The project was dropped when it was apparent that the new Royal Horse and Field Artillery would take up the majority of any budget, as well as manufacturer designs not meeting the Government's accuracy requirements.<sup>495</sup> It was not until 1907 that interest again appeared for a field howitzer. There was not a qualitative enough jump yet in technology to allow for such public expenditure in re-outfitting. The range of the 5-inch howitzer meant that, to hit a trench, it would have to be within the range of every field gun in Europe, and thus it has to be assumed that this weapon would only be for use outside Europe, against non-modern equipped forces.<sup>496</sup>

Initially, the War Office saw the project as being able to increase the supply base, after Coventry was successful in winning 18-pr orders. In this procurement, Coventry submitted the 4.5-inch howitzer, Vickers submitted a 4.33-inch howitzer and Elswick submitted a 4.7-inch

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<sup>495</sup> SUPP 6/63 Annual reports of the president. 1904. 3.

<sup>496</sup> SUPP 6/61. Annual reports of the president. 1902. 51-52.

howitzer, and the Royal Gun Factory submitted a 5-inch howitzer.<sup>497</sup> The Howitzer Committee preferred designs from the Royal Gun Factory, Elswick, and Vickers for a new field howitzer, and rejected proposals from Cammell and Beardmore, and only liked the breech from Brown's. Oddly, a later submitted modified design from Coventry was accepted. This seems in violation of normal procurement rules. In the 1907 testing phase, the 4.5-inch howitzer programme the Coventry designed howitzer won. The design, though after being submitted to the Royal Gun Factory, was recommended to be modified for manufacture due to the extreme difficulty of producing the piece to the tolerances as designed by Coventry. The attachment of the jacket was the primary culprit.<sup>498</sup> This howitzer, and its difficult design was a perpetual difficulty through 1917.

The operational testing of the 4.5-inch howitzer was uniquely striking in the damage that could be achieved by a Lyddite shell on hardened targets. The howitzer in testing in November, 1908 was able to destroy bombproofs at 6,000 yards. This capacity showed first the development of high explosive since 1902, and second, the quick development of fuzing for the said shells that made the battlefield much more dangerous.<sup>499</sup>

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<sup>497</sup>SUPP 6/544. Extracts from proceedings Royal Artillery Committee. 21.

<sup>498</sup> SUPP 6/163. Annual report of the president. 1908. 13.

<sup>499</sup> SUPP 6/544. Extracts from proceedings Royal Artillery Committee. 17-18.

### Evolution from 4.7-inch guns

The 4.7-inch gun had been the mainstay of British long range field artillery in the Boer War. The gun gained a reputation in the popular press as being a lifesaver for British forces, although the technical staffs knew it as an obsolescent liability that needed to be replaced. The project that replaced it was the 60-pr gun.

A new 4.7-inch gun had been testing for many years and was being developed in 1904. This was to replace the 4.7 Marks I-IV of 2,175 feet per second muzzle velocity by one of 2,744 with MD Cordite and 45 calibres. This project became the basis of the procurement of the 60-pr. The problem in this particular gun was that the driving band could not be made strong enough to keep the projectile accurate without exceeding working pressure.<sup>500</sup> A 4.7-inch gun in 45 calibres, especially when being designed for India, would have been an exceedingly heavy gun. The 40-calibre variants were used by the Royal Navy in South Africa, and coastal batteries. Trials of new rifling of the 4.7-inch gun were based upon experiences gained with the 6-inch Mark VII.<sup>501</sup>

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<sup>500</sup>SUPP 6/63. Annual reports of the president. 1904. 60.

<sup>501</sup> SUPP 6/60. Annual reports of the president. 1901. 2.

## The 60-pr gun

Lord Roberts, the Commanding General in South Africa, submitted a request in September 1900 for heavy batteries for use in South Africa. The ensuing request for 5-inch guns in lieu of the standard 4.7s was probably the genesis for the 60-pr programme. His request was for a range of 10,000 yards, with a weight no more than 80 cwt for the entire gun, carriage, and limber, and as large a shell as possible. This was believed to be a difficult task of accuracy at long distance with shrapnel as well as short range targeting. All three manufacturers were asked to submit plans, with Chief Superintendent, Ordnance Factories and Elswick submitting the heaviest guns at 39.5 cwt and Vickers with 36 cwt. The Vickers gun was the smallest in weight and length.<sup>502</sup>

Essentially, the 60-pr was a long range version of the 18-pr. It was to deliver shrapnel to 10,000 yards, 4,000 yards further than the 18-pr. was designed to do.<sup>503</sup> The 60-pr gun program was a disappointment for Vickers, who failed to impress. Elswick produced a good product which was accepted. The munitions were also selected from the Elswick submission. Vickers produced a 5-inch BL gun that did not meet the company's promises, as well as not meeting specification. It was

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<sup>502</sup> SUPP 6/61. Annual reports of the president. 1902. 45-47.

<sup>503</sup> SUPP 6/62. Annual reports of the president. 1903. 207-208.

constructed with ‘curious’ functions, which appeared to not be a positive feature, and failed the tests at Salisbury.<sup>504</sup>

Two days after Christmas in 1906, the Chief Superintendent, Ordnance Factories remarked that the German designed Erhardt Howitzer of 12 cm was very competitive against the 60-pr when it came to weight. The howitzer weighed 24 cwt. in the field, whereas the 60-pr weighted 91 cwt, and only gained a 15 pound projectile weight and less than 3,000 yards in range. He believed both were necessary, and that South Africa proved the viability of two separate weapons, but he did start obviously thinking about the possibilities.<sup>505</sup>

As part of the success of the 60-pr for field use, on 15 January 1914 the Director of Naval Ordnance asked for a new naval service 5-inch (60-pr) with quickfiring ammunition and a sliding block mechanism. The Royal Gun Factory, Vickers, Beardmore, Elswick, and Coventry all submitted designs.<sup>506</sup> The Royal Gun Factory, Beardmore, and one of the Vickers designs were selected for trials.<sup>507</sup> The war would put this procurement on hold, and it appears to have been dropped by the time it could be implemented.

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<sup>504</sup> Ibid. 192.

<sup>505</sup> SUPP 6/67. Annual reports of the president. 1907. 474.

<sup>506</sup> SUPP 6/169. Annual report of the president. 1914. 260.

<sup>507</sup> Ibid. 261.



## Howitzers

The heavy howitzers and guns made up the siege train of the army. This was designed to crush fortifications, but it took time, often days or weeks, to bring up. As it was a specialist artillery, little time or money was actually spent on it, although the experiments that were conducted were some of the most important in the pre-war period. By 1914 Britain went to war with a haphazard array of weapons listed below in a diverse state of readiness and obsolescence.

### 9.2-inch Siege Gun

The first requirements for a long range piece in the field came from the Director General of Ordnance (the predecessor position of the Master General of Ordnance) on 20 February 1901. He requested a new requirement coming directly from gunners in South Africa for high angle guns with a range of about 15,000 yards. He requested the Ordnance Committee should look at any current guns to fit this requirement although it was desirable to have these made out of 9.2-inch guns. The Ordnance Committee responded that the 9.2 Marks III to VII would comply with the requirement. The selected guns had three ways to get the key parameter envelope of performance, although in actuality only two would have the

muzzle velocity (and therefore range) needed. First, they should have a full charge and an angle of descent of 39.5 and elevation of 26 degrees. Second, they could also achieve an angle of elevation theoretically of 60 degrees and 80 degrees descent, essentially plunging fire, although such a carriage would be an engineering marvel if even possible. Thirdly, the committee stated that a  $\frac{3}{4}$  charge could theoretically give a muzzle velocity of 1,660 feet per second, and an angle of 45 degrees, with descent being 56 degrees. The committee asked what the final use was for this system, to which the Director General of Ordnance responded that ‘These guns were specifically required for use against batteries placed behind hills or concealed in folds of ground. They would not be required for ranges of less than 6000 yards.’<sup>508</sup>

In the research phase, designs for a 9.2 inch arcing shot gun, which took an old gun and remounted it to 45 degrees, (which gave between 9,000 and 15000 yards calculated range), dropped it at 56 degrees, as the requirement called for low velocity, high angle.<sup>509</sup>

Major Minchin, the Army’s rifling and mathematics expert, conducted rifling experiments on these new high-velocity guns in 1902 and concluded that the uniform rifling was just as accurate, if not more, than

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<sup>508</sup> SUPP 6/60. Annual reports of the president. 1901. 41-42.

<sup>509</sup> Ibid. 1.

experimental and new increasing rifling.<sup>510</sup> This sort of rifling did not have a uniform pitch, although it increased in angle as the rifling approached the muzzle. The guns achieved thorough results at 5,695 yard range with 8 ¾ pounds powder at 35 degrees, and 5,942 at 45 degrees, and 14,489 yards with 37 pounds powder at 35 degrees and 14,950 at 45 degrees. The guns were wildly inaccurate at full charge, with an error of 274 yards in range, but only a 9.6 yard error in direction. The gun was deemed too inaccurate in its current rifling pattern, and was rebored and rifled with a design designed for high angle fire. This new bore found much better results, achieving a 5,949 yard range with 8 ¾ pounds powder at 40 degrees and 6,022 at 45 degrees, and 15,226 yards with 37 pounds powder at 35 degrees and 16,140 at 45 degrees. The guns were wildly inaccurate at full charge, with an error of 72 yards in range, but a 28.22 yard error in direction. In addition to tweaking the rifling, a new shell was also tried. The 3.8 calibre service shell was part of the cause of the inaccuracy. It was tried again with a shorter 3.1 calibre shell with more success.<sup>511</sup>

Although artillery, especially siege and naval artillery, involved cutting edge engineering, users were not afraid of using simple techniques that worked, and the 9.2-inch gun demonstrated this brilliantly in a dialogue with the Ordnance Committee. The testers at Shoeburyness

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<sup>510</sup> SUPP 6/61. Annual reports of the president. 1902. 89.

<sup>511</sup> Ibid. 40.

discovered that the shell was sliding out of the gun at high angles, so the shell had to be held in the barrel with a stick. ‘It was found at Shoeburyness that when loading at high angles of elevation the projectile slipped back into the chamber when the rammer was withdrawn, and to prevent this a stick was employed’, and ‘They asked the Superintendent of Experiments, Shoeburyness, whether he saw any objection to the use of the stick, especially in view of the fact that the cartridge would have to be made up of several portions’, to which the reply ‘The Superintendent of Experiments saw no objection’<sup>512</sup> was given.

The high velocity 9.2-inch gun was finally deployed in 1903. It was sent to Gibraltar for deployment. The gun worked best with a 35 degree firing solution and a 288-pound shell of Lyddite.<sup>513</sup>

The eventual successor would take over a decade to emerge, and would not even take the form of a gun, but that of a howitzer. The results of a solicitation for the new 9.2-inch howitzer were sent to the Ordnance Factories, Elswick, Vickers, Coventry, and Beardmore on 31 October 1910, resulting in the Board accepting the OF as the most likely solution. The requirements were: 10,000 yard range, 3.5 calibre length shell, burster

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<sup>512</sup> Ibid. Appendix 16.

<sup>513</sup> SUPP 6/62. Annual reports of the president. 1903. 6-18.

of 55 pounds, 11 ounces, and Cordite MD.<sup>514</sup> The final result, started a decade earlier would be the go-to Army level gun on the Western Front.

### 9.45-inch Skoda Howitzer

The Czech arms firm Skoda sold the British Government at least four 24 cm Mörser M 98 howitzers, which were subsequently renamed 9.45-inch Howitzers in British service. Unlike almost all other ordnance buys near the Boer War, the wealth of evidence was that Vickers bought the forgings directly from Skoda, and then sold them on to the British government. There was a problem though in this arrangement. The forgings did not contain the requisite chemical composition and it appears that Vickers were not completely trustworthy in their fronting of the requisite clauses to make sure that the foreign made forgings were in compliance with British inspection regulations. The forgings were rejected and all other work suspended. All guns already built were to be chemically tested. This experience, along with others that are not mentioned in the detailed report might have led to the limiting of metals and forgings from outside the UK, one of the key testing points in British forgings between

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<sup>514</sup> SUPP 6/166. Annual report of the president. 1911. 115.

1900 and 1914.<sup>515</sup> Skoda forgings brought about the double testing of steel, both mechanically and chemically.<sup>516</sup>

The 9.45-inch howitzer had development problems due primarily to it having a working pressure of 13 tons, which gave 928 feet per second in muzzle velocity, about half the speed of a contemporary British gun. Shells were filled with ‘dynamo’, which was more stable than Lyddite, and the shells as such could be treated as filled with powder.<sup>517</sup> This would have also limited the effectiveness of the howitzer.

After the defects of the Skoda built 9.45-inch howitzers were made known, a new 8.5-inch howitzer project was started. The specification was to have a muzzle velocity of 1,150–1,200 feet per second, a range of up to 10,000 yards, and a 300 pound projectile. The requirement was taken up by the Royal Gun Factory and was in the works at the end of 1902.<sup>518</sup>

A 9.45-inch howitzer was being built, weighed 5 ½ tons for gun and gun limber, and by the summer of 1908 was doing road tests with a traction engine to North Wales from Dover.<sup>519</sup> Tests at Lydd were conducted to determine what happened to fortifications when a high explosive shell was fired at them, mainly the effects of splintering and the goal of bettering gun

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<sup>515</sup> SUPP 6/60. Annual reports of the president. 1901. 9–10, 89–92.

<sup>516</sup> SUPP 6/61. Annual reports of the president. 1902. 11.

<sup>517</sup> SUPP 6/63. Annual reports of the president. 1904. 68.

<sup>518</sup> SUPP 6/61. Annual reports of the president. 1902. 44.

<sup>519</sup> SUPP 6/544. Extracts from proceedings Royal Artillery Committee. 30.

emplacements, but also much was learned on how to conduct bombardments. Tests used 6 and 9.2-inch shell.<sup>520</sup> These tests conducted on the 9.45-inch affected both the 9.5-inch and the 9.2-inch howitzer projects.

Although not operationally a success, the 9.45-inch howitzer was a success in tightening bureaucracy and contract clauses. Due to its failure, the introduction of chemical tests on forgings helped bring about a revolution in steel that ended with the introduction of the nickel steel specification. It also laid the ground work for the heavy howitzers that would be needed in the next war.

### **8.5-inch Howitzer**

The Ordnance Committee wanted a heavy howitzer that had both the range and firepower to attack fortified targets. This was very much to be taken from the experiences of South Africa. One model was an 8.5-inch Howitzer, of which one was created. The results of the 8.5-inch howitzer road tests demonstrated that it was too heavy for all but the most ‘sound’ roads, and even then it was difficult. The design was all but thrown out after the test as a completely new carriage would be required. The Skoda howitzer weighed almost half as much, and the new howitzer was

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<sup>520</sup> SUPP 6/60. Annual reports of the president. 1901. 169-170.

even more awkward than the 8-inch already in service. It is very likely that the failure of this 8.5-inch howitzer, started the basis of development for the 9.2-inch howitzer.<sup>521</sup>

### **9.2-inch Howitzer**

The 9.2-inch howitzer was started through the merging of several needs for which several weapons had been experimented with though none had been adopted for production. One of these was a new 9.75-inch heavy howitzer being proposed in 1906. On 13 January 1906 Vickers submitted a design for the heavy howitzer competition, but it was rejected, with Coventry, Beardmore, and Brown being selected for trials of design.<sup>522</sup> Although the 9.75 had been authorized, it did not appear to have a single copy made, although it was important as the winning design was the first heavy howitzer to have the Royal Gun Factory design being made out of nickel steel.<sup>523</sup>

The next step was on 30 March 1910 when the Director of Artillery sent out letters to Elswick, Coventry, Beardmore, Vickers, and the Ordnance Factory for a proposed design and specification for a new heavy

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<sup>521</sup> Ibid. 164-167.

<sup>522</sup> SUPP 6/66. Annual reports of the president. 1906. 257.

<sup>523</sup> Ibid. 68.



siege howitzer.<sup>524</sup> A design committee was formed to work on a new heavy howitzer. This would be a 9.2-inch howitzer, with ranges from 2,500 to not less than 10,000 yards. It was to have a 290 pound shell minimum, 60 degree traverse, and a simple design that could withstand rugged terrain.<sup>525</sup> Elswick, Brown, Coventry, Beardmore, Vickers, and Royal Gun Factory all submitted designs for the heavy howitzer.<sup>526</sup> The winner of these experiments was still in the testing phase in 1914 when war broke out. The prototype, 'Mother', was sent to France, and now resides in the Imperial War Museum.

### 6-inch Howitzers

In 1901 tests of the 6-inch 30 cwt howitzer were conducted to lighten the shell from 122.5 to 100 pounds. It was found that the lightening of the shell afforded a range increase from 5,000 yards to 7,310. It was also found that the error in range was 168.8 yards, at 45 degrees, making it not a terribly accurate weapon. The 100 pound shell was not as accurate as the standard shell, but at 28 and 36 degrees, the accuracies were within a satisfactory range. The tests results were found to be acceptable, and the service charge of 100 pounds was accepted by the Director General of

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<sup>524</sup> SUPP 6/165. Annual report of the president. 1910. 104.

<sup>525</sup> SUPP 6/65. Annual reports of the president. 1905. 317.

<sup>526</sup> Ibid. 318.

Ordnance.<sup>527</sup> No orders are listed in the contract books from 1900–1914 for this howitzer either with the Trade or at Woolwich. The accuracy issues were probably a primary reason why it did not receive investment and by 1914 was obsolescent compared to other siege armaments.

### Railway Guns

Railway guns were considered one aspect of the heavy siege train. The Ordnance Committee tried to mount a 6-inch howitzer in 1902 to a railway carriage, although this effort was abandoned. The 6-inch railway trials were reopened although they were going slowly, mainly because it was believed that a 6-inch gun was too energetic for the tracks, and 4.7 and 60-pr guns were suggested instead. Logistically, it was thought undesirable to shut down rail lines to fire guns, and that they would have to have their own sidings. There are reports in the next chapter that this was due to railway guns using a track 1-inch wider than the normal Western European standard gauge.

The development of the 6-inch guns was interesting as these were not for home defence and the customer was different from in most other operations. The General Staff did not comment on the project, which in

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<sup>527</sup> SUPP 6/60. Annual reports of the president. 1901. 15.

itself is a comment on how effective those outside the technical field saw railway guns.<sup>528</sup>

In the end, the 6-inch railway gun tests were a failure as the 60-pr made it obsolescent, but the Committee suggested continuing work for mountings of 7.5 and 9.2-inch railway guns.<sup>529</sup> Elswick designed railway mountings for 9.2-inch guns that were submitted to the Director of Artillery who forwarded them on 27 August 1914. These apparently were to mount spare proof and evaluation guns.<sup>530</sup> In addition, the 12-inch howitzers to be mounted on railway carriages were to use a 750-pound high explosive (TNT) shell versus the service 850 shell.<sup>531</sup> The heyday of railway artillery would have to wait for more funding that was a direct result of warfare.

## Conclusion

The experimentation and development of ordnance in the period from 1900 to 1914 demonstrated a constant cycle of improvement based upon scientific principles and a willingness to adapt new materials and processes. Naval guns almost doubled in size over the period, while the army's guns increased in range and power. The service which was pinned

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<sup>528</sup> SUPP 6/66. Annual reports of the president. 1906. 262.

<sup>529</sup> SUPP 6/65. Annual reports of the president. 1905. 15.

<sup>530</sup> SUPP 6/169. Annual report of the president. 1914. 279.

<sup>531</sup> Ibid. 392.

down by Boer artillery at the start of the period had substantially increased its holdings of long range artillery, even going as far as to take guns that had once been reserved for siege trains and adapting them for new uses. The period also demonstrated several great examples of how interservice synergy was used to create guns that incorporated lessons learned from the other service. All of the experimentation and redesign built up an infrastructure that ensured that British ordnance was well designed, safe, and was effective on the whole. It also produced a vast amount of knowledge for both industry and the services about how guns could be modified for the best manufacturing techniques. The guns that equipped the British armed forces in 1914 were the product of experience, experiments, and evolution. They shaped the services, and drove how the British would fight in the next conflict, known as the Great War.

## **CHAPTER NINE: INITIAL MOBILIZATION: THE OUTBREAK OF WAR THROUGH THE END OF 1914**

### **Introduction**

War arrived in Europe on 28 July 1914. The United Kingdom did not declare war until 4 August 1914. The British, like all entering the war, did not know the scope or duration of the conflict. This point must be constantly reinforced if we are going to analyse the decisions made and when they were made. This is especially important in contracts, as they are a product of a particular time, need, and availability, or perceived availability.

This chapter will discuss the events from the declaration of war for the British government through the end of 1914. It will focus on the immediate response to a system shocked by not only war, but also the new issues of industrial conflict including a degraded workforce depleted by military recruitment, increased industrial demand, and the opening of governmental funding. It will work through the first months of uncertainty, and the contracts that were placed by the end of the year for the initial outfitting of a British force for an anticipated need.

## **The Government Staff**

Contracts, procurement, and acquisitions were and are inherently based upon human interactions. Without staffs, contracts are not written, and such was the case for the British Government in August 1914. The civil financial staffs, the uniformed officers in technical roles, and their suppliers were leaders of mobilisation on the outbreak of war.

The business of finding the armaments to take the country to war did not lie in the hands of the Generals and Admirals. In many ways, they also did not lie with the politicians who declared war to begin with. The single group that was issued the task were a select few individuals in Whitehall. The civil staffs had always dominated procurement, in peacetime and wartime. Partly due to their permanent assignments, they were ideally suited to take jobs where consistency and experience were paramount.

## **The War Office**

The organization of those who dealt with the issues of payment and contracts were all focused under the Financial Secretary of the War Office. The position had existed in its current guise since the creation of the Army council back in 1905. Although the Financial Secretary was a Minister of

Parliament (MP), the day to day work of the office was run by his assistant, Sir Charles Harris.

Sir Charles Harris, as the Assistant Financial Secretary to the War Office was the professional civil servant who was the institutional memory of the department. Since 1908 Harris had led the War Office's financial affairs, through three political Financial Secretaries.<sup>532</sup> Harris was charged with managing the civil staffs of the office that built and executed the estimates and votes of the War Office. His primary qualification before entering the position was that of the chief financial auditor of War Office votes, and yearly he led the audit of the Royal Factories. He knew the business of finance, but also the business of ordnance, as he had worked closely with the Chief Superintendent of Ordnance Factories, Hay Frederick Donaldson regularly.

Harris had three primary staffs under him that executed the business of the Financial Secretary, the Director of Army Accounts, the Director of Contracts, and the Director of Financial Services. Each of these positions was a long-standing bureau within the War Office, and without them, nothing happened. That set these three particular positions apart from much of the bureaucracy surrounding ordnance. These men had long service contracts and had grown up in the system of clerks, most likely

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<sup>532</sup> Army List, January 1909–July 1914.

requiring a tour as a second-class clerk, before becoming a first class clerk, and eventually being a Principal before taking leadership.

JA Flynn, Esq CB, occupied the office of Director of Army Accounts since January 1905, when the position was created along with the Army Council.<sup>533</sup> Unfortunately, there is little known about Mr Flynn, as he did not leave papers, and he did not receive an obituary that survives today.

HD De la Bere, Esq CB, was the director of Contracts for the War Office. Like JA Flynn, De la Bere had held the position since 1905 as the only Director of Army contracts in the Army Council period. As part of the agreements with the Treasury in the 1880s, De la Bere was given the task of procuring guns for both the army and navy until 1909 when his office reverted the execution of the Vote to the newly formed Navy Contracts Office. De La Bere was replaced in the fall of 1914, and took up a job as a Commissioner of Inland Revenue which was effective by at latest 1 December 1914.<sup>534</sup>

De La Bere was replaced by UF Wintour as Director of Army Contracts. He had come over from a position at the Board of Trade. Wintour would stay in the position until the spring of 1917, when he was superseded by WA Bland, a long serving Principal of the finance bureau.<sup>535</sup>

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<sup>533</sup> Army List. January 1905.

<sup>534</sup> *The London Gazette*. Issue 28992. 1 December 1914, 10201.

<sup>535</sup> Army List. January 1906, January 1908.



Finally, WP Perry was the director of Financial Services. Bland was elevated from Principal for Accounts in 1908 to take over for De La Bere, as the latter had both positions from 1905–1908.

The most important work of the Finance Department was undertaken by the Principals. These clerks were the most senior civil servants that handled between them all financial matters at the War Office. Before the war, this position had been rearranged several times, with the 1905 iteration being one Principal for Contracts, five Principals for Finance, and four Principals for Accounts.<sup>596</sup> In 1909, the Principals for Finance and Accounts were combined to make a general pool of seven Principals for the department, although the Director of Contracts kept his single Principal for Contracts.

Of the three financial offices of the War Office, by far the most important of the three to the study of ordnance in wartime was that of the Director of Army Contracts. It is his work that will be cited in this thesis.

Unfortunately for historians, little is known about anybody other than Sir Charles Harris in the War Office financial bureaucracy. Part of this was because they, in the tradition of the Civil Service, did not leave papers. This cog-in-the-machine mentality meant that they have been understudied for their role in the war. Many of them were decorated with

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<sup>596</sup> Army List, January 1906

CBEs or CBs after the war, although to First World War historians their work has become background and taken for granted, since there was not a failure in the office during the war.

### The Admiralty

At the Admiralty, Rear Admiral Frederick Tutor was just completing his tour as the Director of Naval Ordnance (DNO). He had impressed the King, and was to be assigned the First Battle Squadron, although this was speeded up. His replacement was Rear Admiral Morgan Singer. Singer had already had one tour as a member of the Ordnance Committee, as well as being the Commanding Officer of HMS *Excellent*, the Royal Navy gunnery school, and had just come off a year as Aide De Camp to the King.

Little is known about the contracting side of the Admiralty after 1909. The papers do not survive at Kew outlining the contracts or personnel, and due to the way in which civil staffs were recorded in the Navy Lists, there is not the level of detail about the financial staffs as there is for the War Office. The only clues left remain in the audits and order books of the Royal Gun Factory, which only give a partial view of the orders placed.

## The State of the Trade

The Trade in July 1914 was working on a plethora of complex contracts, although mainly for foreign customers. Since the introduction in 1905 of the 13 and 18-prs into the Royal Horse and Field Artillery respectively, no major home orders for field artillery had been placed, with the exception of a few 4.5-inch howitzers. Any orders received for the trade therefore came from Admiralty Votes.

Vickers largest project was the newly laid down HMS *Revenge*, a massive 25,750 ton Superdreadnought that was designed to be the biggest British battleship ever.<sup>537</sup> The company had recently launched the HMS *Emperor of India*, one of four in the *Iron Duke* class. The only major project Vickers was working on for the army at this time was an experimental replacement to the Short Magazine Lee Enfield, or SMLE, the main rifle of all British and Commonwealth servicemen. The new rifle would have replace the venerable .303 British cartridge with a smaller, more modern .276 cartridge.<sup>538</sup>

Armstrong meanwhile was finishing the *Almirante Latorre*, a 28,000 ton battleship mounting 14-inch guns for Chile. In addition, Armstrong

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<sup>537</sup> Ian Johnston and Ian Buxton. *The Battleship Builders*. Barnsley, UK: Seaforth Press, 2013. 135

<sup>538</sup> Luke Mercaldo. *Allied Rifle Contracts in America*. Wet Dog Publications: Greensboro 2011. 132-133.

was finishing the HMS *Malaya*, one of five *Queen Elizabeth* Class Superdreadnoughts, the first British ships outfitted with 15-inch guns and oil-fired furnaces, making them less likely to be seen than older coal-fired dreadnoughts.<sup>539</sup>

Beardmore, as a shipbuilder first and foremost, was the most reliant on Admiralty orders of any of the big private firms. The company had just received its first large gun contract for the 15-inch battleship guns of the *Queen Elizabeth* class in Fiscal Year 1913. July 1914 saw two capital ships building in the works, HMS *Benbow* was being outfitted, as HMS *Ramillies* was being laid down. The company was also building three *Arethusa*-class light cruisers, giving a sense of the scale of operations on the Clyde in the summer of 1914. By July 1914, there is no record of Beardmore ever contracting directly with the army for anything other than ‘A’ tubes for building up guns at Woolwich.<sup>540</sup>

Coventry Ordnance had last produced a gun for the army in FY 1910 with the 4.5-inch howitzer that they had designed in-house.<sup>541</sup> They had received an order from the Admiralty for 26 4-inch Mark VII breech loading guns in FY 1914, an order that would have been well towards completion by July 1914. The company’s last major gun contract was for

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<sup>539</sup> Johnston & Buxton. *The Battleship Builders*. 134–5.

<sup>540</sup> WO 395/2 Annual Reports 1903–1908.; WO 395/3 Annual Reports 1909–1914.

<sup>541</sup> WO 395/3. Annual Reports 1909–1914.

four of the 13.5-inch guns in FY 1913, at £11,300 each. The company received no orders for 15-inch Mark I guns for the initial order for the *Queen Elizabeths*.

### The Ordnance Factories

In July 1914, Major General Sir Stanley von Donop, KCB, RA, had been the Master General of Ordnance for just over a year. The 54-year old had been appointed on 11 Feb. 1913 to the position, which also allowed him to sit as the fourth member of the Army Council.<sup>542</sup> Von Donop was arguably the most experienced manager of technical requirements in Britain at the time, previously serving as the Professor of Artillery at Woolwich in 1900 as a major, and serving as Secretary of the Ordnance Committee from 1905–1907. Von Donop had also served in the last war on the artillery staff in South Africa.

The Chief Superintendent of the Ordnance Factories oversaw the execution of one of the largest budgets of the government, as well as several thousand civilian and military staff spread through factories across the country. Sir Henry F. Donaldson had maintained the position (as well as the position of Chief Mechanical Engineer) since 1903, and had overseen the execution of the Murray Committee's reforms and strategy as well as

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<sup>542</sup> *Edinburgh Gazette* 14 Feb 1913. Issue 12538, 175; *The Times*, 18 Oct 1941. 6.

having been an active onlooker to the complexities of the world's arms advances.<sup>543</sup> As one of the highest civilians in the Ministry of War, Donaldson oversaw that the Royal Navy and British Army were issued with quality arms that only his inspectors could sign off on. His mind in July 1914 would have been focusing on not only the execution of budget, but also managing the new 15-inch Mark I naval guns for the *Queen Elizabeth* class battleships and on whether Woolwich would be expanding to make the 60-foot behemoths.

Overall, in July 1914, the vast majority of the work that was being done on Government contracts by British industry took the form of naval contracts. Not a single large project was being procured by the army in this time. It is no surprise that when war broke out the army would have to either displace naval orders or build or hire new capacity to cope with its needs. This balance would challenge all pre-war work, from policy all the way to design and training, and everything in between. The success of delivering weapons to the end user community would determine in large part the success or failure of the British and Allied campaigns in the Great War.

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<sup>543</sup> SUPP 5/1036 List of senior staff 1888-1926 and historical enquiries.

## Government Position with Suppliers

Most critiques of the Army's procurement system, especially after the 'shells crisis', were that the Government were too comfortable with the Trade, especially Vickers and Armstrong. Records indicate that this was all but a barefaced lie for political ends. As early as 1902, the Director of Naval Ordnance had specifically pointed out that he would rather order at Woolwich than go out to the trade, as the Trade was more costly and in many cases more expensive than what he could get at the supposedly inherently inefficient Royal Factories. This had changed somewhat by 1909 when Reginald Bacon took over as DNO, although it was due primarily to accounting changes since the Murray Report that increased the percentage paid by votes and not by the quality of the guns being made.<sup>544</sup>

The key basis of an industrialized war was that the leaders of such a war saw industrial capacity, production, and results as a center of gravity to the conduct of operations and final victory. With this as a major aspect of the first weeks of the Great War, one must argue that indeed the conflict against Germany was the first industrial war Britain had fought. The shift from personnel to material priorities would become the greatest difficulty on the bureaucratic front.

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<sup>544</sup> Reginald Bacon. *From 1900 onward*. London: Hutchinson & Co, 1940. 168.

## Naval Requirements at Outbreak

Naval requirements came in two distinct forms. First, guns were needed to outfit new vessels that were being built in yards. Second, guns were required to replace those damaged or worn out. The latter need was much smaller than the first. As the Royal Navy went on a wartime footing, little actually changed in the needs of ordnance for the fleet. Ships that would be commissioned in the next several years already had their guns ordered, as the lead times could be several years to complete a full set of armaments. As the Royal Navy could not quickly increase its vessel count, its need for new armaments was much less than that of the British Army. In addition, the war reserve built after the Boer War allowed more flexibility in naval contracts and capacity. The new vessels that were armed were primarily merchant vessels. These armaments had been pooled for over a decade, with some vessels even carrying their armaments in peacetime in the hold so that they could be armed without having to travel back to Britain.

As to the second need, the Royal Navy actually fired very few shells during the war, especially in comparison to its land based counterparts. There was only one pitched battle involving the entire fleet, although there were several instances where individual vessels heavily engaged the enemy,



such as HMS *Invincible* at the Battle of the Falklands on 8 December 1914. The largest campaign in regard to expenditure was in support of the amphibious assault in the Dardanelles, although most shells fired were not full charges, and therefore barrel wear was much less than it would have been against naval targets. Additionally, the vessels assigned to the bombardments were older pre-dreadnoughts that had already been removed from the battle fleets, and were considered obsolete for front-line naval use.

During the war, the Director of Naval Ordnance assumed the duties of design and inspection of naval ordnance from the Chief Inspector at Woolwich.<sup>545</sup> This ended a dominance of design for naval ordnance dating back to the 1880s, and required time to ease into the new position. Slowly the roles of inspection, design, and contracts were assumed by the Admiralty staffs as more capabilities were acquired. Arguably, this was a task that although maturing, was not fully integrated by the end of the war.<sup>546</sup> The DNO staff only amounted to 16 officers and petty officers at the outbreak of the war, and thus to find the time to complete orders for current guns, fix problems in the fleet, and design new guns required skill and attention, and lots of long hours. This would wear this small cadre of officers down, prompting a wartime reorganization, which, four years later,

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<sup>545</sup> ADM 116/1849 Naval Ordnance Department.

<sup>546</sup> Ibid.

was still in transition. Even including the administration staff of clerks, writers, and typists, the staff only comprised 50 souls all in.<sup>547</sup>

Even the size of the naval ordnance inspection department was small. Only nine officers were employed to inspect all naval ordnance over the entire country.

In a somewhat cryptic request, the DNO on 20 August 1914 requested relining designs for 12-inch Marks XI, X, and XII, 13.5-inch Mark V, and 9.2-inch Mark XI and 7.5-inch Marks II-V.<sup>548</sup> This should have been well known to the DNO, unless he was thinking of diversifying into other manufacturers. In addition, this signalled that the battle fleet would lose the *QE* class and newer boats as well as the pre-dreadnoughts that carried the Mark IX. The Master General of Ordnance stated in a memo dated 15 October 1914 that it was the Admiralty that had ordered 9.2-inch guns mounted on railway carriages, and suggested that the most that could be ordered due to capacity of the manufacturer was six. He proposed using some of these mounts to also put in the field a 12-inch howitzer. The benefits of the heavy howitzers were that they fired almost twice the weight (410 versus 750) and were just as mobile, but also stated that it would be five months for a howitzer to be delivered.<sup>549</sup>

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<sup>547</sup> Ibid.

<sup>548</sup> SUPP 6/169 Annual report of the president. 1914. 279.

<sup>549</sup> Ibid, 398

Although the naval requirements in August 1914 were not great, the sister service would see an exponential spike in its needs.

### Army Requirements at Outbreak

On 1 August 1914, the British Army had in its possession: 126 13-prs, 624 18-prs, 128 4.5-inch howitzers, 28 60-prs, 81 6-inch 30 cwt howitzers, one 9.2-inch howitzer, 164 4.7-inch guns, 150 5-inch howitzers, 623 converted BL 15-pr guns, 85 15-pr QF guns, and 10 2.75-inch guns.<sup>550</sup> This was the basis for arming the six regular divisions, the Territorial Army, and any siege units of the Royal Garrison Artillery that had been attached to the force.

The needs of the armies though were somewhat driven by the size and style of divisions in the army. The army needed 24 13-prs per cavalry division, 54 18-prs and 18 4.5-inch howitzers and four 60-prs per infantry line division.<sup>551</sup> The recruitment of new units forced this to be rethought. The K Armies of the 'Kitchener Army' had four battalions in lieu of three for the old divisions, but with only 48 18-prs, every brigade now only had 12 guns instead of 18 in the original British Expeditionary Force. This gave

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<sup>550</sup> WO 161/23 Statement of ammunition. Appendix III Possession at Outbreak of War; also numbers since received and numbers still due. 2 June 1915.

<sup>551</sup> WO 161/22 New Armies: Arms and ammunition. 1914-1915.

each division much less artillery support as compared to that of the original British Expeditionary Force. This also meant that as there were many fewer guns in the ratio of men to guns, the K divisions were considerably less capable when it came to artillery support. With that being noted, it also meant that the supply of guns was much relieved. A K division could be sent to France with 24 fewer guns as compared to that of the old divisions, and for every two new divisions, a third one could be created from the amount that would have been required. The issuance of four guns per battery is not mentioned by the Master General of Ordnance as being either a temporary industrial fix, or a permanent solution, but by the end of 1914 the ratios had been set out, and the orders had been placed.<sup>552</sup> The howitzers per division would revert to two batteries of four each for a total of eight initially.<sup>553</sup> The other weapons classes would remain to be seen, but artillery above division was to be dealt with later. It was not a worry in 1914 to any level of the field guns.

The British Army ordered 480 18-pr guns in March 1905. To completely outfit the British Expeditionary Force, 324 guns would be needed. In addition, the 'Mowatt Reserve,' a strategic reserve that had existed since the new guns had been delivered, included 90 18-pr guns

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<sup>552</sup> Ibid.

<sup>553</sup> Ibid.

held as strategic reserve at Woolwich, along with their reserve munitions.<sup>554</sup>

It is not currently known where the remaining guns were held, which on a conservative estimate would have numbered at least 76.

### Siege Guns

The introduction of medium howitzers was the subject of the 7 November 1914 meeting of the Siege Committee. What came out of this committee was the acceptance of the 8-inch howitzer converted from the 6-inch guns. They calculated that although the howitzer was relatively light in projectile weight, heavier artillery might not be necessary in breaking through the Rhine defences. The defences were the primary reason for initially choosing the heavy 10-inch howitzers that nobody seemed to like (and were never built) due to both their excessive weight and clunky carriages.<sup>555</sup> The Committee though still in 1914 had the mentality of a short war that required the use of a Victorian era siege train for the purposes of mopping up the defences of the Rhine. This was what drove the orders for ordnance in 1914, with the request being submitted for 32 heavy (over 750 pound shell, or 12-inch), 48 medium (300-400 pound), and 60 light (6-inch) howitzers to total the siege train.

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<sup>554</sup> MUN 5/179/1200.1/3 Minute on shortage of 4 5' and 9 2' high explosive shell.

<sup>555</sup> WO 161/22 Interim Report of Major-General Hickman's Siege Committee.

The siege committee on 14 Oct proposed converting the old 6-inch Breech Loading Converted (BLC) guns into 8-inch (200-pr) howitzers. This was proposed apparently due to need for medium howitzers in the field as well as the lack of 10-inch/9-inch Rifled Muzzle Loading (RML) guns, of which there were four and not the 18 promised.<sup>556</sup>

These are the only guns mentioned by the siege artillery in 1914, the 12-inch howitzer, the 9.2-inch gun, and the converted 6-inch BLC guns

In October, both Vickers and Armstrongs submitted designs for 12-inch howitzers. Both appear to have been given the production go-ahead very quickly, and were to build separate designs of their choosing as long as both fired a standard cartridge.

### Contracts

The war forced the Government to expand the size of the forces. This affected the British Army most. The requirement of outfitting the new divisions was approached through the traditional view that the easiest way to procure equipment was to go directly to the proven firms that could provide artillery for the needs of the newly expanding army. Therefore, all the contracts for artillery in 1914 went to firms that had a proven track record.

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<sup>556</sup> SUPP 6/169. Annual report of the president. 1914. 403.

Major General Stanley von Donop, the Master General of Ordnance, described the process of the War Office work in the first few months as follows:

‘On August 10<sup>th</sup> Orders were issued for the necessity equipment and ammunition for the 1<sup>st</sup> New Army.

In September then further New Armies were ordered to be raised and equipped further orders for both Guns and Ammunition and for the necessary ammunition were placed. By this time the policy of employing the resources of Canada had already been taken up and order given.

In October it was recognized that not only was a much larger number of guns required but that the number of rounds per gun found to be necessarily exceed by a large amount that previously thought to be adequate. Orders were at once placed for the guns and the questions of how the large amount of ammunitions required could be obtained, was closely considered’<sup>557</sup>

The three time periods of von Donop’s letter above show that the Master General of Ordnance and the Army Contracts Department saw the mobilization in three distinct periods. Indeed, the contracts as listed below also demonstrate and verify the orders. The first contracts for the August mobilization were placed with the Ordnance Factories. The September

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<sup>557</sup> LG C/5/7/27 Letter S.B. von Donop, War Office, to Mr. Lloyd George. 20 April 1915.

requirements for the New Armies was placed in the first weeks of October, with a final set of contracts being placed in late October. Like the armies being raised, this last tranche of contracts was also the largest.

The role of the Master General of Ordnance is key to understanding the decisions made in mobilization. The Master General of Ordnance at the outbreak had the final say in what ordnance stores were purchased for the armies. In an undated letter to George Gibb early in 1915, von Donop laid down his requirements for more equipment, although all new orders were not to interfere with those orders already placed.<sup>558</sup>

### **Contracts Placed in Opening Months of War**

In this next section all of the contracts placed in the first year of the war will be discussed. They are broken down by the item being produced. These numbers are based upon the Army Contracts Department's records book, and cross referenced by the Ministry of Munitions classified contracts book created in 1915 and 1916. There is no evidence to suggest that it is incomplete, although some contracts for artillery not placed by the Director of Army Contracts might be missing, such as those ordered by the Royal Navy, or orders in North America placed by firms such as J.P.

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<sup>558</sup> WO 161/23. Statement of ammunition. Appendix III Possession at Outbreak of War; also numbers since received and numbers still due. 2 June 1915.



Morgan, although the only known North American orders are included in the notebooks.

It should be noted that the dates listed below for each order are based upon the date that the final contract, including the negotiated price, was executed. Many of these contracts were given preliminary approval to await price negotiation later. For instance, Contract #G 1624 for 16 9.2-inch howitzers from Vickers was signed on 7 October 1914, although the order and permission to start manufacture was given on 4 September, a full month before.<sup>539</sup>

### 18-pr

The 18-pr made up the majority of orders placed with the firms. All contracts placed for 18-prs placed in 1914 were for Mark II variants. The initial contract was placed for 168 guns with the Ordnance Factories under contracts 57/3/4247 and 57/3/4435. This contract was let on 22 August 1914, less than 3 weeks after the declaration of war. The placement of orders with the Ordnance Factories showed that indeed the policy set forth in the Murray Report back in 1907 was being executed. The purpose of the contracts was twofold, first they allowed for an extra three divisions

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<sup>539</sup> LG F/191/2/2 Notes by Major-General Sir Stanley von Donop on the supply of munitions to the army. 11 August 1919. 5.

worth of artillery to be produced in the only factory that had produced any 18-prs in any size of production run since at least 1907. Second, they warmed up the supply base and trained workers on the platform. This would be, with one exception of an order for 30 guns on 18 January 1915, the only recorded order to the Royal Gun Factory for new 18-prs for the duration of the war. The orders therefore were designed to prepare the workforce for the coming deluge of repair work that the Ordnance Factories would conduct.

The second half of the execution of the Murray Report was to then fully mobilize the private factories belonging to the mature and proven Trade. Vickers and Armstrongs both received orders for 1,000 18-prs each in the opening months of the war. Vickers contract G 1691 was issued on 16 October 1914, whilst Elswick received their contract, G 1724 on 27 October 1914. These were massive contracts and would have required extensive outlay in plant to comply in time. Each of these contracts was almost twice the size of the previous largest contract ever signed in peacetime, the initial order for the 18-prs back in March 1905, and that contract was split over three different manufacturers. In regards to that previous contract, the third firm in 1905, Coventry Ordnance Works, did not receive a single order for 18-prs throughout the period of War Office control. An additional round of orders was received by both Vickers and

Armstrongs on 11 January 1915. This order, G 1993, would see an additional 450 guns per company. Finally, Vickers received an order from the Canadian Government for 150 guns sometime in the first months of 1915.<sup>560</sup>

As part of the widening supply base, Beardmore received their first contract for field pieces on 5 January 1915. This order, S 7083, was for 200 guns, and was increased by another 70 under G1993 on 11 January 1915.<sup>561</sup> Beardmore had already built 15-inch superdreadnought guns, but this was the first known field piece contract. In addition, Beardmore was 50% owned by Vickers, and so they were able to access assistance ‘in-house’ which allowed them to enter the field much faster than other would be entrants.

Only one other contract for 18-prs was executed in 1914. The Bethlehem Steel company of Bethlehem, Pennsylvania, USA, under the control of businessman Charles Schwab received an order for 100 guns. This order, placed on 19 November 1914 directly to the War Office Director of Army Contracts was the first order for field pieces made outside Britain in the war. In addition, under the same contract, but stated after the initial contract, the order was raised to 200 guns. It was stated that

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<sup>560</sup> WO 161/23. Statement of ammunition. Appendix III Possession at Outbreak of War; also numbers since received and numbers still due. 2 June 1915.

<sup>561</sup> Ibid.

this increase of 100 was for the Royal Navy. It is not recorded if the Royal Navy took delivery of these guns, or if they were immediately transferred to the Royal Artillery. In the campaigns which the Royal Navy could have used such pieces, such as the campaigns in eastern Africa or at Gallipoli, there are no records of naval crews utilizing the new pieces. It is also the only known artillery contract recorded in the entire war or which the Royal Navy used an existing army contract to increase for its own use.<sup>562</sup>

In total, at least 3,718 18-pounders were ordered between August 1914 and the end of January 1915.<sup>563</sup> This represented a massive mobilization of extreme proportions. To compare, Wellington's allied command at Waterloo a century earlier had a combined total of 156 guns.<sup>564</sup> The total number has historically been under represented in secondary works. For instance, Hew Strachan's *The First World War* states the number of guns ordered by 21 October 1914 at 878 although the actual numbers to that point were at least 2,168.<sup>565</sup> This underrepresentation is due directly to the source: the Official History of the Ministry of Munitions, which had a vendetta against properly

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<sup>562</sup> Ibid.

<sup>563</sup> Ibid.

<sup>564</sup> David Hamilton-Williams, *Waterloo, New Perspectives, The Great Battle Reappraised*. New York: John Wiley and Sons. 1994. 256.

<sup>565</sup> Strachan, Hew *The First World War: Volume I: To Arms*. Oxford: Oxford University Press, 2003. 1067.

representing the effectiveness of the contracts placed by the War Office before May 1915, as justification for its existence and effectiveness.

### 13-pr

The other field gun, the 13-pr, did not receive nearly as many orders as its bigger brother. As with the 18-pr all ordered variants were for the Mark II pattern guns. Vickers was given an order for just 18 guns on 5 December 1914. This order, G 1855, would be the only apparent order to the trade for the entire war, although Canada ordered 24 guns, also to Vickers, sometime before 15 May 1915.

The Ordnance Factories also received an order for 100 13-prs, under contract 73/4/6561, although this order was only placed in May 1915, which might hint that these were intended for replacements as much as new units, and might hint at the difficulties of relining the original guns made in 1905 as much as anything else.<sup>566</sup> Although not clear, these last 13-prs ordered from the Ordnance Factories could also have been the basis for work to create the high angle anti-aircraft (AA) model 13-pr that was being stood up about this time. If this is the case, this order would fall out of the purview of the study of this thesis.

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<sup>566</sup> WO 161/23. Statement of ammunition. Appendix III Possession at Outbreak of War; also numbers since received and numbers still due. 2 June 1915.

### 4.5-inch Howitzer

The 4.5-inch howitzer was to be the second most issued gun to British divisions. To fully outfit units, one howitzer was required for every three field guns. As the howitzer was originally designed by Coventry Ordnance Works, they received all orders placed in the trade. The first order was placed on 13 October 1914 under two separate contracts, G 1653 for 200 howitzers, and G 1718 for 100 howitzers. In addition, by the end of the month, another 150 howitzers would be ordered under contract G 1748. By the end of January 1915, another 200 howitzers had been ordered from Coventry, with contract G 1993 executed on 11 January 1915. This contract seems to have been converted for some reason on 24 April 1915 to 94 G 32, which does not appear to be anything more than a conversion of nomenclature rather than a new contract. These 650 howitzers were the only orders for the field howitzers before the end of 1915 to the trade.<sup>567</sup>

In addition to the Trade, less than ten days after the declaration of war, the Ordnance Factories were given orders for 112 4.5-inch howitzers. These three contracts, 57/3/4259 for 30, 57/3/4435 for 50, and 78/4/6500 for 32 were all placed on 13 August 1914. It is unknown why the three

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<sup>567</sup> Ibid.

contracts were placed separately, but by looking at the delivery dates, it might have been a way to have a tiered system of delivery, with some of the contracts having definite delivery dates, whilst others did not. This meant, if war concluded quickly, that the War Office could cancel whole contracts, whilst also having full delivery of others, instead of managing one large contract, and only executing portions of it. This is only speculation though, as no records of the thought process of contract strategy survive. It can only be surmised from the existing contract summaries as well as the delivery schedules by contract.

Canada also ordered 4.5-inch howitzers in FY 1913, although on its own terms. It requested that they be made by Coventry Ordnance Works, and that it should be able to purchase the said howitzers under last year's pricing. This was initially denied by the Director of Army Contracts, H. De La Bere. When Canada insisted on its demands being met, they also issued an ultimatum that if this was not possible, it would cancel the order entirely. De La Bere still insisted upon the procurement under the proper competition rules, and Canada cancelled the order request in March 1913.<sup>568</sup>

The underestimation in the Official Records mentioned earlier for the 18-pr also occurred with the 4.5-inch Howitzer. Quoted as 150 orders

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<sup>568</sup> WO 254/1. Contracts Precedent Book.

before 21 October 1914, the actual number was almost treble that at 421.<sup>569</sup>

The constant underestimation of War Office orders is disturbing to this study for two reasons. One, it has skewed the narrative since 1921 for all historians since that point to perpetuate. Secondly, if the Ministry actually believed its own numbers, it could have been a primary reason why Lloyd George and his followers so blatantly misunderstood the scope of what had been done and the state of industry in the country. This latter view could have been true in 1915, although there was almost no possibility of this by 1921 when the Official Records were published, and therefore the Ministry's historians deliberately underrepresented their predecessors work. These points are more than enough to take the entire Official History of the Ministry of Munitions with suspicion at best and as a work of historical fiction at worst.

### 60-pr Guns

The Corps level artillery was to be dominated by the 60-pr guns. Contractually, the 60-pr was acquired in a different format from the Division level artillery. A 5 October 1914 contract, G 1779, ordered 36 guns each from Elswick and Vickers. The element that made this

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<sup>569</sup> Strachan, *The First World War*, 1067; WO 161/23. Statement of ammunition. Appendix III Possession at Outbreak of War; also numbers since received and numbers still due. 2 June 1915.



procurement different was that it appears the Government tried using a contract format similar to a Blanket Purchase Agreement (BPA) or an Indefinite Delivery Indefinite Quantity (IDIQ) type contract. This was due to both companies receiving the same contract number for the 60-prs. This might have actually been a carry on from the contract placed for the 18-pr recapitalization contract of 1905, which used a similar contract method.

In addition, the Ordnance Factories were given two orders, one for 36, under 73/3/7993 dated 11 October 1914, and seemingly updated on 5 November 1914 as 57/3/4435, and an additional one for 40 sometime in the spring of 1915 listed as 73/3/8081.

The remaining contract listed in the contract books for 60-prs was issued to Vickers on 19 February 1915 for 12 guns for Canada, to follow the end of the initial contract production. There is also one contract to Elswick issued sometime before 12 June 1915, although it only appears in Ministry of Munitions papers, and does not give a production amount.<sup>570</sup>

The problem with the contract production schedule listed above was that it was woefully small in comparison to the needs. There was either a serious void between production and need, or several contracts were missing from the files. Either could be true, but it is much more likely that

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<sup>570</sup> MUN 7/463. Lists of variations from approved gun designs.

records do not survive for the additional guns needed and ordered before June 1915.

### 6-inch, 26-Cwt Howitzer

The larger 6-inch howitzers were latecomers for contracts. It was not until 5 February 1915 that the first contract was issued for these howitzers, and even then, only four were ordered from Vickers. Another 16 were ordered on 19 February 1915.<sup>571</sup> These are the only known orders for these howitzers in the pre Ministry of Munitions era.

### 8-inch Howitzer

The 8-inch howitzers were not new build howitzers, but a conversion from the old 6-inch BLC guns bored out to take the larger shell. These would prove to be effective both in regards to resource allocation of industry as well as making it possible to use otherwise obsolete equipment for new purposes that could help the war effort. They would eventually be replaced by the 9.2-inch howitzers as they became available. The conversions were completed by four factories under the same contract number, 73/3/8037. Elswick, Beardmore, and Vickers each received

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<sup>571</sup> WO 161/23. Statement of ammunition. Appendix III Possession at Outbreak of War; also numbers since received and numbers still due. 2 June 1915.

orders for four, three, and four respectively, on 31 December 1914. A few days later, the Ordnance Factories were contracted to convert 12 effective 14 January 1915.

### 9.2-inch Howitzer

The 9.2s were still in experimental stage when war broke out. The first, 'Mother', was shipped to France for several months in late 1914 for quite literally operational testing. Vickers were awarded the only known War Office contracts, for 16 on 7 October 1914 (G 1624), and another 16 on 31 October 1914 (G 1746).

### Short War?

One of the most contested topics of the First World War among historians is that of whether those in charge planned for a short war or a long war. Contracts are one of the few places where an insight into that decision making can be analysed. By looking at the contracts placed by the War Office, we can conclude it was highly unlikely that those writing contracts for delivery dates over a year after thought that the war would be over by Christmas. What goes even more against such an assumption is that due to a decade old contract, British planners were able to have at least 10 divisions in the field with artillery, even though only six were then

budgeted. The orders for new artillery would not arrive until December at the earliest delivery date, and most of the initial contracts did not have primary partial deliveries until April 1915.<sup>572</sup>

### Comparisons to Policy

There are no other contracts that are known to have been executed in the period between August 1914 through May 1915 for service with the British Expeditionary Force. The contracts for armaments for naval service do not appear to survive at all. Contracts for guns placed after May 1915 are limited, but the procurement of guns under the Ministry of Munitions will be discussed in the following chapter.

In final comparison, the contracts placed by the War Office were actually quite bold in their scale, and fitted well into the pre-war policy. The working thought in almost all western nations was that it would take 18 months for a country's industrial base to go from cold to full capacity. The British assumption that the Royal Gun Factory at the Ordnance Factories would produce the majority of guns in the first six months before conversion to repair work was completely compatible with the size and scope of the contract placed in the first few weeks of the war. The question

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<sup>572</sup> Ibid.

after the mobilization though would be whether 1915 would show consistent production in a timely manner, and if the assumptions that British industry could fight an industrial war were right assumptions. It would not be known until the summer of 1915 if Britain had a fighting chance of winning the war from the factories.

### Effects of Woolwich

Woolwich traditionally had an audit every year which was published for the use of the House of Commons. This had been suspended in the Boer War, although an audit of contracts was indeed executed in 1902 that complied with the spirit of the annual audits.<sup>573</sup> This policy was again followed, and only a very limited report was produced, of a handful of pages, whereas the peacetime reports were often over 400 pages long. In the end, no audit report for the wartime years was ever completed, which adds a complexity to understanding the actual output of Woolwich during the war. We cannot follow the especially important work of relining and repair which contracts were not formally written for, and no financial data survive for this work. As stocks varied through peace and war, it is not even possible to calculate the quantity of work based on the purchase of individual tubes. Unfortunately as well, the records of secondary suppliers

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<sup>573</sup> WO 395/1 Annual Reports 1873-1903. 6.

seem to have not survived, and even records of completed new-build artillery are spotty at best.

The establishment at Woolwich was the lynchpin of mobilization, yet some tasks were woefully understaffed. For instance, the Inspection Department maintained all sealed drawings for government-accepted designs. In 1906 the Department had just one army captain on this requirement, and it was only one of many assigned duties. As the department was not reorganized between then and 1914, when the war broke out, only one person would have still been given that assignment. Without drawings, no guns could be built, and no contracts could be written.<sup>574</sup>

Unusually, a 12-inch Mark IX was sent to Beardmore's to be relined. The Inspector of Steel reported a fracture in the tube on 12 Nov 1914. This must have been a wartime expedient. It does seem to prove though that the Royal Gun Factory was the primary centre, as Beardmore cracked the tube when trying to get it out. This proves that it was a specialized task that is not related to manufacture.<sup>575</sup>

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<sup>574</sup> WO 33/2960. Report of the Committee appointed to consider methods of inspection and delivery of naval ordnance and naval ordnance stores. 75.

<sup>575</sup> SUPP 6/169. Annual report of the president. 1914. 255.

## **Scientific Research**

In the opening months of the war, most research was usually commissioned and completed by the Ordnance Board. Due to the requirements of the services to have guns proofed and accepted quickly, staff who would normally have worked on research were given the task of inspecting and accepting new guns. The ranges at Shoeburyness were at full capacity with work on production guns, and therefore little research and design occurred during the war. British designers took the point of view that it was better to have a clean production of identical pieces instead of inserting improvements into the contract, which would slow down production. This was in hindsight a clever decision, as it allowed for a streamlined production which could integrate suppliers without having to alter tooling or train staff on new tasks.

## **End users**

As a note to readers, the design and purchasing was done as mentioned before primarily by the Ordnance Board, on the orders of the Master General of Ordnance, and executed by the civil staffs of the Army Contracts Division. The Army Ordnance Corps were not involved at all in design. They were used exclusively in the field as a sort of intermediary

between the Royal Artillery and Woolwich Arsenal. The force was commanded by a Captain or Major, and was primarily composed of senior enlisted engineers who were trained to fix things that could be fixed in the field, as well as for preventative maintenance and checking on barrel life. They were not by our definition strategic forces, and did not normally operate in wartime in Britain, and therefore will not be mentioned again.

### Activity in the United States

In the first few months of the war, the United States maintained its role as a neutral, although neutrality almost always favors one side over another. Because of unrestricted access to the sea, Britain had the upper hand in ordinary US exports. The British Ambassador to Washington, Sir Cecil Spring Rice, theoretically ran all communication in and out of the country. In reality, the war progressed with such *vitesse* that it would be impossible for a diplomatic office to control all business deals between the two states. By looking at the accounts books of the Embassy, it appears that most of the efforts of Sir Cecil's staff concerned ascertaining information about German shipping out of Philadelphia and other ports. His staff was too small to directly send operatives, so the embassy contracted out to the Pinkerton Detective Agency to watch over all major ports on both the east and west coasts and gather intelligence. The Embassy for example spent



\$5,202, or roughly £1,200, every three weeks on this contract alone. These activities were paid out under Secret Service funds made available under the Foreign Office. Certainly the human intelligence collected by the embassy would have had some effect on calculations of the industrial capacity of Germany's supply chain outside of Europe, as well as providing a better understanding of the movement of goods and contract values in negotiation.<sup>576</sup>

## Conclusion

The first months of the war were critical to the successful outcome of the war. The Murray Report from 1907 outlined the strategic industrial policy of the War Office in times of war and peace, and from all indications the War Office executed it to plan at the outbreak of war. The Ordnance Factories took large orders in the initial weeks of conflict that allowed industry time to mobilize, expand, and produce the equipment needed for a European war. The initial contracts placed with the trade were executed in a timely manner and the actual ledgers of the War Office show that indeed the contracts were placed with firms that were likely to comply with the quality, quantity, and time of the critical contracts. The

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<sup>576</sup> FO 1093/60. Foreign Secret Service Accounts 1914-1915: operations in the USA.

only failure of the Murray Report, and therefore War Office policy was that it could not have predicted in 1907 that the British Army would swell from six divisions to seventy-five.

The Royal Navy was better positioned for the oncoming war. As a service that relied on long term investment and the consideration that ships unlike men, cannot be recruited quickly, the Royal Navy was unable to expand in the way that the army did. The policies put in place after the conclusion of the Boer War gave the fleet a substantial pool of reserve guns. As the fleet developed technological advances to lengthen the lives of its main guns, the need for replacement became less acute. The fleet by the end of 1914 had yet to engage the enemy's main fleet, and therefore had not placed industrial pressure on the Trade or Woolwich. Naval orders for new ships required their ordnance to be ordered years in advance, and therefore the long term needs were already being built when the war commenced.

## **CHAPTER TEN: LABOUR ISSUES, POLITICAL SOLUTIONS, AND THE TEST OF 1916**

### **Introduction**

As the new year came and went, the guns on the front continued to blaze. 1915 would be the first year of a material war, as all sides had now started to see the benefits of months of industrial mobilization. 1915 would also see a number of crises that would shake the way industry related to the government. This chapter follows the problems and successes from the beginning of the year until the creation of the Ministry of Munitions at the end of May, 1915. It then assesses the war under the Ministry of Munitions until the summer of 1916. This chapter discusses how the war for mobilization and sustainment evolved. This chapter will also cover the last of the great arms contracts, which coincided with the entrance of the Americans and the exit of Imperial Russia from the Great War.

The most challenging of these was that of labour, which took up the most time of the governmental and trade staffs, with increasing contracts, although the continuing war on land as well as the relative quiet of the war at sea led to challenges that were not planned at Whitehall. This was followed by a period of intense need for ordnance, with the summer 1916 campaigns which also included the only major naval battle of the war.

Finally, this chapter will discuss the end of the war for ordnance procurement for all intents and purposes by the spring of 1917.

### Naval Needs

The needs of the Admiralty into 1915 had somewhat changed from what they were in August 1914. The threat of commerce raiding on the extensive British Merchant Marine diminished day by day as lone German cruisers were swept from the seas. The destruction of the German East Asian Squadron under Admiral Maximilian von Spee off the eastern coast of South America in December 1914 removed the final major enemy combatant force afloat outside of home waters. This victory had eliminated or at least lowered the need for smaller guns to arm merchant vessels against other surface threats. These had been a large portion of the pre-war requirements of the Royal Navy, and the needs consisted mainly of 4.7-inch guns and 6-inch guns for the larger vessels like Cunard Line's RMS *Mauretania*. The Royal Navy therefore had the primary threat shifted to a consolidated force in the form of the German High Seas Fleet waiting in harbour. Meeting this required big guns, guns with the ability to hit and damage capital ships. At this point, this meant only guns of 13.5-inches and above. The shift allowed some capacity to be freed for medium guns of the army patterns desperately needed in France.

## Army Needs

The largest need in the first months of 1915 was not the 18-pr, but the 4.5-inch howitzer. The field howitzer had been designed to plunge high explosive shell upon bunkers and other obstructions, although the production of the gun was proving difficult. By May 1915, only 16 divisions worth of howitzers could be accounted for, while at the same time, 25 divisions worth of 18-prs were available. Even more worrying, only 5 divisions' worth of ammunition was available for the howitzers. The May estimates predicted that by August, only 28 divisions of howitzers would be available, although fewer than half of those would have the munitions needed. This was compared against 41 divisions' worth of 18-prs and 43 divisions' worth of the heavy 60-pr guns.<sup>577</sup> By the summer campaign, the decision to allow Coventry Ordnance Works to almost exclusively produce the 4.5s was showing as a bad decision.

## 4.5-inch Howitzer Issues

The failure of Coventry to mass produce the 4.5-inch howitzer has never been fully explained. As it was not produced under wartime contract by any other firm, except the 112 ordered from the Royal Gun Factory,

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<sup>577</sup> LG C/1/2/17 General Von Donop's statement as to the supply at certain dates of ammunition and rifles and table of supplies. 17 May 1915.

Coventry cannot have their experience judged by the experience of their peers. Part of the problem might have been tied to the departure of the head of the firm, Admiral Reginald Bacon, who had been called back to active service soon after the outbreak of war. One reason for the difficulty with the 4.5-inch howitzer in the field was that the rate of prematures was one in 5,000 rounds fired. This was in comparison to one in 27,650 for the 18-pr. The problem was the fuze, although this still meant that it was statistically almost impossible for a 4.5-inch howitzer to make it to the point where it needed relining.<sup>578</sup> The 4.5-inch howitzer had also been offered to the Russian forces. 300 had been promised in February, March, and April of 1916, although as the Director of Naval Ordnance stated 'You will see, therefore, that it is most unfortunate that the howitzers selected to be given to the Russians should have been of the nature which has given us more trouble than any other gun or Howitzer in working up the supply of ammunition'.<sup>579</sup>

### **Political Decisions**

In February 1915, shipyard workers on the Clyde went on strike for, among other things, a wage that would be able to meet the rise in labour

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<sup>578</sup> Hew Strachan. *The First World War: Volume I: To Arms*. Oxford: Oxford University Press, 2003. 1084.

<sup>579</sup> WO 161/23. Statement of ammunition. Letter dated 20/12/15.

costs over industry as a whole due to wartime shortages. This industrial action was met through arbitration led by Sir George Askwith, the Chair of the Government Arbitration Committee.<sup>580</sup> Lloyd George though at the same time appeared to have grander ideas. Lloyd George seemed to believe that the Government was in the midst of nationalizing the shipbuilding industry due to the strikes. In a letter written sometime very close to 15 March 1915 from Francis Dyke Acland, the Financial Secretary to the Treasury, to John Bradbury, the Permanent Secretary to the Treasury, Acland outlined that Walter Runciman as head of the Board of Trade was seriously considering taking over the armaments firms.<sup>581</sup> It is unknown how far this plan actually progressed, but it must be taken into account when discussing the ‘shells crisis’ which came into public discourse about a month later. It is also significant that Lloyd George was given a copy, and although it is unknown when that copy was given, it was almost certainly at the time it was originally written.

The issue of strikes during the war after the Clyde actions was settled relatively quickly. The Government committee that Askwith chaired recommended that industry be more sympathetic to labour and that labour in turn not strike. This would have never worked in peacetime, although the conditions had changed in a year of industrial war. In a meeting at the

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<sup>580</sup> Paul Addison. *Churchill on the Home Front 1900-1955*. 1993, 156.

<sup>581</sup> LG/C/1/2/10 F.D.Acland,to Bradbury. Typescript copy 14 March 1915.

Treasury from 17–19 March 1915, many of the most important unions were represented, including the Amalgamated Society of Engineers, the primary union for gunmakers. This conference confirmed that the Unions would agree not to strike on contracts for warlike stores during the war, although they were under no legal obligation to do so.<sup>582</sup> As there was no legal requirement, this also meant that non-union shops were under no requirement or obligation not to strike, although by 1914 non-union shops were virtually non-existent in the warlike stores industries.

### **Wear of Guns**

The shells crisis gives historians another view into the issues involved with guns themselves. A 16 March 1915 report shows that from August 1914 through 27 February 1915 672,732 shells had been expended in France from 324 guns, or roughly three times the original amount taken to France. In addition, from that date until 16 March, 128,727 rounds had been fired. There were still 398,125 rounds left on hand in France, or roughly six weeks' worth based on previous expenditure.<sup>583</sup> Although this is interesting for the shells crisis, it also demonstrates that the guns were wearing out. Assuming every gun had fired an equal amount, which of

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<sup>582</sup> WO 254/1. Contracts Precedent Book 94/G No 34.

<sup>583</sup> WO 161/23. State of 18-pr: Q.F. Ammunition 16<sup>th</sup>:March 1915.



course would never be the case, by 16 March, the average 18-pr expenditure had been 2,473 rounds. In addition, based upon the expenditure of shell in the first two weeks of March, 397 rounds had been fired on average in just 17 days. The life of a barrel was assumed to be 6,000 rounds at this point, so barrels would have to be replaced every 260 days, with this meagre expenditure of 23 rounds a day. This meant that every 18-pr that went to France in 1914 would have to be replaced by August 1915. And these assumptions are based upon them not firing a single round before being delivered, although they had been in service for a decade by this point. It should be noted that the French army was able to complete missions militarily with 20 rounds per gun per day to keep within the needs of the service. The Commanding General of the BEF, Field Marshal Sir John French, had stated back to Whitehall that no less than 50 per day would be sufficient in January 1915.<sup>584</sup> 50 rounds a day would mean even in quiet times, an 18-pr would wear out in 120 days. This expenditure was both not sustainable, and strategically a failure due to the gun wear. There is no doubt that French threw out the number for political reasons, as anybody familiar with the technical needs would have and did brush the number aside as impossible to fulfil in both shells and barrels, and not needed in the field.

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<sup>584</sup> WO 161/23. 121/Stores/1214. January, 1915.

This wear rate was a substantial issue that seems to have eluded the Chancellor when the Government was calculating the needs of the army. For instance, a note dated 19 May 1915 from the Committee on Munitions showed that the Committee calculated the needs of munitions based solely on the total amount of guns in possession of the country as a whole and their delivery based upon no wastage.<sup>585</sup> The exclusion of relining or other work to guns out of service was not calculated. This also meant that divisions were either below strength in their guns, or that the new divisions were not able to be engaged due to lack of artillery. Under strength units also had the accounting trick of having more rounds per operational gun than should have been. This was because the rounds for inactive guns would have been distributed to those who could have fired them. This would also have had an effect on the guns themselves, as to fire the same amount of munitions; fewer guns would have fired more rounds, thus wearing out single guns faster.

### **Woolwich**

The demands on Woolwich were multifaceted. It was only the key producers at initial mobilization, but it also served as the sole manufacturer

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<sup>585</sup> LG/C/1/2/17. General Von Donop's statement as to the supply at certain dates of ammunition and rifles and table of supplies. 19 May 1915.

that could conduct relining. Wearing out of gun barrels became its primary job in the spring of 1915. Its work came from two sources, first, natural wear, and second, blown barrels caused by unsuitable contractors of shell and fuze. Little could be done about the latter, as by the spring, quantity had taken over for quality, as mentioned earlier. Natural wear could be calculated, although it became exponentially more important as more divisions were put into combat.

Each gun after being relined, as well as all new guns needed to be proofed, or fired at 120% of service pressure, to verify quality. The restrictions on proof butts at government facilities become a burden by the spring of 1915. Woolwich only had 2 proof butts with which it had to test all new guns with several shots, as well as carrying out the tedious work of testing every lot of powder to confirm it was ballistically true to the specification. This was done by firing guns loaded with the powder from the lots with very precise measurements to confirm the powder produced the correct thrust, among other things. This affected gun production in various ways. First, it took up the precious pits at Woolwich where final gun inspection took place. Secondly, every powder size required a different gun, which also had to be within the first quarter of its life, which also meant a constant turnover of guns back to the RGF for relining.

## Financial Decisions

The largest financial decision in the opening months of the war in regards to ordnance was the Treasury's appointment of Messrs J.P. Morgan & Co of New York, NY as sole commercial agents for his Majesty's Government. This agreement was signed on 15 January 1915 in the Treasury.<sup>586</sup> This consolidated six months of frustrating work to try to eradicate the speculators and war profiteers that the War Office representatives had encountered in the first months of the war. Signing the document and appointing Morgans as the sole representatives meant that contracts could be negotiated in New York, and that those contracts were backed by the financial weight of Morgans, with their expenditure itself backed by holdings in the Bank of England, as per the agreement. Although vastly important for the provision of powder and shell for the BEF, Morgans were not terribly important in regards to artillery itself. Complete artillery was only purchased in a few select contracts and those were put into effect directly between the War Office and Charles Schwab's Bethlehem Steel. It is much more difficult to calculate the effect of imported raw materials as well as finished steel ingots on the artillery trade,

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<sup>586</sup> LG/C/1/2/7. Copy Agreement appointing Messrs. J.P.Morgan and Co. the agents of H.M.G. in United States. Typescript copy 15 Jan 1915.

as it is not even possible to trace the same within the domestic supply chain.

By the end of June 1915, \$350,000,000 of war related goods had been shipped from the United States to the Allies.<sup>587</sup>

### **Industrial Decisions**

Woolwich was probably as representative as any factory producing heavy ordnance during the first months of the war. Sir Charles Harris had commented in the 1902 First Account of the Committee of Public Accounts that during the Boer War 10% was the normal annual write-off for machinery. He commented in his 1915 report that from August 1914 to March 1915 33% of the factory at Woolwich had to be written off as the machinery was being worked to destruction. A wearout rate of four times that of the previous war, and many more times that of peacetime showed not only the stretched nature of Woolwich, but also that the policies of the Murray Report were being put into true effect.<sup>588</sup> In addition, Woolwich inspection staff had to make sure that every contract and every contractor received the most up-to-date drawings available. In the first year of the

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<sup>587</sup> F. Carrington Weems. *America and Munitions; The Work of Messrs. J.P. Morgan & Co in the World War*. New York: Privately Printed. 1923 4.

<sup>588</sup> Public Accounts Committee. *First Report of the Committee on Public Accounts*. (London, UK: House of Commons, 1902. 196.

war, 'no fewer than 134,000 copies of sealed drawings have been prepared and sent out.'<sup>589</sup>

### **Shoeburyness**

As was expected Shoeburyness simply could not cope with the needs of a mobilized industry, and the work of proofing was devolved to the manufacturer ranges. It was noted that 90% of new gun proof work was done at the ranges owned by the companies themselves. This was conducted by the assistant inspectors who had been stationed at the manufacturer facilities.<sup>590</sup>

### **Production Rates**

Guns were rolling off the production lines, albeit at a restricted rate. It was planned that starting in April 1915, a full Army worth of field artillery could be produced every month until the British armies were complete in September 1915, with seven entire armies equipped with new equipment. To June 1915, 732 18-prs had been produced. To complement, 160 4.5-inch Howitzers, 36 60-prs, 40 Mark VII guns, 23 8-

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<sup>589</sup> MUN 5/1900/5. Documents transferred from the Ministry of Munitions.

<sup>590</sup> MUN 5/122. Inspection.

inch howitzers, and amazingly, 18 9.2-inch Howitzers had been produced.<sup>591</sup> These numbers though represent a building rate that is constantly growing at an increasing rate. More of these guns were probably produced in June 1915 than in almost any other month. Nonetheless, it showed that the calculation that mobilization would take 18 months might be beaten by actual output. British industry had built enough field guns to outfit 15 divisions, or almost three times the number of divisions outfitted with 18-prs at the output of the war.

### **Status by May 1915**

The early months of 1915 were somewhat quieter than they should have been. Contractors were supposed to be producing at their maximum rate, with the goal of the entire British armies being outfitted by the summer campaigns. This did not happen, for multiple reasons, although the largest single issue was the failure of industry and Government to maximize skilled and unskilled labour. This failure would make the technical problems take a secondary theatre to the political fighting that would erupt into the public domain under the guise of the 'shells crisis' in March 1915. The issues of labour would cause the creation of a new Ministry as well as the most significant challenge to the bureaucracy of how

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<sup>591</sup> MUN 5/179. Minute on shortage of 4 5' and 9 2' high explosive shell.

ordnance was procured since the crisis caused by the Crimean War in 1855.

### **The Ministry Period, May 1915**

The political instability caused by poorly calculated labour decisions brought about the most serious shock to the British armaments industry of the war in May 1915, with the creation of the Ministry of Munitions. The rise of David Lloyd George coincided with a fall of the War Office staffs, with the eventual demise of both Lord Kitchener and Stanley von Donop in a little over a year. The rise and fall of the great leaders of British armaments will be analysed in this chapter.

### **Genesis of the Ministry of Munitions**

Chris Wrigley wrote in 1982 that ‘the Ministry of Munitions’ record is such that it is unlikely ever to be subject to drastic revisionism. The problem with much of the writing about the ministry is that it tends to overstate matters, presenting the ministry almost as a revolution in government’.<sup>592</sup> Wrigley’s argument was based upon a long-standing entrenchment of the myth of the role of the ministry during the war, due

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<sup>592</sup> Wrigley, Chris. ‘The Ministry of Munitions: an Innovative Department.’ In *War and the State*. Edited by Kathleen Burk, 32–56. London: George Allen & Urwin, 1982. 33.



primarily to publishers only releasing one side of the story. This would remain entrenched until the works of David Edgerton in the 1990s.

The most important single event in the war for British munitions was the creation of the Ministry of Munitions, along with its first Minister, David Lloyd George, who was appointed on 25 May 1915.

The genesis of a cabinet level ministry was the Treasury War Munitions Committee that was floated by David Lloyd George as a way of alleviating the labour shortages for munitions work. The creation of the Ministry was the final reward for the undermining and political manoeuvring of the opposition, especially Liberal David Lloyd George and Conservative (known as the Conservative and Unionist Party formally after 1912) Andrew Bonar Law, even though technically Lloyd George as Chancellor of the Exchequer was squarely in the Asquith cabinet. As Leader of the Opposition, Bonar Law met with von Donop in April 1915 to try to ‘find out what the position really is as regards Cordite’ (emphasis in original).<sup>593</sup> Bonar Law also took a great interest in the procurement of small arms in the war, although this is outside the scope of this study. Bonar Law though did converse with the then Director of Artillery, Col. von Donop, as early as 1912 on the comparison of British artillery with

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<sup>593</sup> BL 37/1/64. From A.J. Balfour, 4 Carlton Gdns. S.W. 27 April 1915.

that of France in a confidential letter dated 29 January 1912.<sup>594</sup> If Bonar Law was able to comprehend the technical matters under discussion with the D of A, he certainly would have been one of the most able minded politicians in high service with the British Government. The same file continued to show that in the 1912 discussions on the defence controversy, he was able to articulate a policy based upon a strong understanding of British policies in regards to manning, technology, and equipment.<sup>595</sup>

Lloyd George had shown a great interest in undermining the status quo, with the War Office in charge of munitions and ordnance manufacture. Lloyd George believed that the War Office should be relieved of duty due to their lack of full mobilization of industry in the first month of the war. That he not only believed this, but wrote to Arthur Balfour in March 1915 with these views, shows that he postured for quite some time before the creation of the Ministry. Lloyd George also fought to make sure that von Donop had nothing to do with the new ministry, ‘placing at the head of this new Executive of an energetic, fearless mind who will not be cajoled and bamboozled by von Donop nor bullied by anyone else.’<sup>596</sup> It was peculiar that Lloyd George lobbied Balfour and Bonar Law for a change at the War Office, as they were the two

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<sup>594</sup> BL 38/B2. ‘Comparison of British and Foreign Rifles,’ by S.B. von Donop. 29 Jan 1912.

<sup>595</sup> BL 38/B6. TS memo. for Bonar Law on the defence controversy.

<sup>596</sup> LG C/3/3/2. Lloyd George, to Mr Balfour. 6 March 1915.

preeminent leaders of the Conservative party, who were in opposition at the time, especially as Lloyd George was the Chancellor of the Exchequer in a Liberal Government under Asquith.

Kitchener saw the creation of a new committee appealing as it could help the labour issues that he had been complaining about since the start of the war and by March 1915 were getting worse.<sup>597</sup> Kitchener was most worried about the creation of an additional agency with bidding power that could increase costs by bidding against others for resources. This was one of the long-standing fears of the War Office, and had led the Treasury in the 1880s to have the Director of Army Contracts manage all ordnance for the RN. With the devolution of naval contracts in 1909, this would make a third bidder in an increasingly squeezed environment. Lloyd George was pressed by Kitchener for answers that this new committee would not act in a way that Army Contracts would find interfering. He quoted an example in a letter to Lloyd George that a factory in Newcastle was fully built and ready for the output of shells except there was nobody to work it. Kitchener saw this as an affront to his ability to complete contracts, as the ever increasing army was starving him of the ability to actually produce for the said army.<sup>598</sup> Lloyd George wanted more contracts placed with firms,

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<sup>597</sup> LG C/5/7/19. Kitchener, War Office, to Lloyd George 26 March 1915.

<sup>598</sup> LG C/3/16/20. Lloyd George, to Winston Churchill. 26 March 1915.

although Kitchener pointed out that the firms were already working at full capacity and increased orders would have to displace existing orders.

### **Personalities**

It is difficult to distinguish in the correspondence between Kitchener, Lloyd George, von Donop and others in the spring of 1915 between the quantitative problems of shells and the qualitative problems of artillery. Lloyd George was most interested in taking over expendables such as shells and to a lesser extent rifles. This might have been simply because the electorate could better understand these things whereas artillery was a high-tech industry that few actually knew about. The letters of all of the players do not differentiate, which can be confusing to students of the subject.

### **Notes on Definitions**

Munitions was used as an overarching title for all equipment from artillery to small arms to ammunition and propellant. The increase of ammunition was a very different task from increasing heavy ordnance. First, only a handful of shops had the lathes, winders, and precision tools to build ordnance, whereas machine shops and other engineering enterprises that were employed with civilian products in the peace could

produce shells when properly trained. These were two separate industries, which the political elites in their writing were unable or unwilling to differentiate between. Even Kitchener failed to differentiate in some of his work. Only von Donop made the point of articulating the differences in his correspondence, although nobody was listening.

### Labour

The growing divide of skilled labour to operate the industries was becoming an increasingly difficult problem to manage. Skilled labour had been in short supply since the outbreak of war, although there was no easy task to make it right. In peacetime, labour issues never rose to the levels of the Ordnance Committee/Board, let alone the Master General of Ordnance or the political level. This lack of skill in managing a finite shortage of skilled labour almost certainly led to the decisions that were taken by those in Whitehall to let the manufacturers deal with it in their own ways. In early 1915, after von Donop had failed to get political assistance with this, he wrote several letters to the Chancellor to try to get more skilled workers. Not surprisingly, Lloyd George was unsympathetic to von Donop's pleas.<sup>599</sup> Almost all of the labour that had been provided to

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<sup>599</sup> LG C/5/7/27. 'Munitions of War. Notes on Action taken hitherto' by Von Donop 4 pp Typescript copy 14 April 1915.

industry was from two sources; skilled British female labour, and Belgian refugees who had come to Britain after the German invasion in August 1914. The problem simply was that there was not enough skilled labour to go around. Businesses that had labour but were not on war contracts were not willing to give up their skilled labour for fear of not being able to bid for war work themselves as well as of how the loss would affect their post-war position in their respective industries. The armaments firms however were initially unwilling to subcontract with these firms as the latter had no experience, as well as no understanding of the strict requirements of the ordnance trade, which simply was not commercially viable in the peacetime economy.

The unwillingness of manufacturers to self-regulate a sort of labour sharing cooperative, along with the inability of the Government to legally force the transfer of workers from one plant, or even one contract, to another led to a frustrated spring 1915 in Whitehall. The Treasury, Home Office, Admiralty, War Office, Board of Trade, and Cabinet Office, or at least some factions generally within those departments, all wanted to control this valuable labour, but all for different reasons.<sup>600</sup>

Some, but not all of the shortage was caused by the volunteering of skilled workers to enlist in the military in the patriotic surge in 1914. This

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<sup>600</sup> Ibid

had a double edged effect, as many of these men were put into units such as the Ordnance Corps, who were then put in charge of maintaining the equipment that they had possibly built. Artificers and armorers were allowed in January 1915 to enlist up to the age of 60, in comparison to 45 for all other trades.<sup>601</sup> In theory this meant that if the skilled labour was used for this purpose, it would save labour for repair work in the United Kingdom. How many of these workers were actually assigned to be artificers though is not known, and is outside the scope of this thesis, although it is worth noting that these enlistments were not always a bad thing.

By 14 April 1915, the War Office was discussing the issue of the earlier problem of skilled enlisted labour, and was proceeding on the basis of the 'return from the Army of individual men of special skill urgently required for work on munitions of war'.<sup>602</sup> This took time, and it took human resources that were also in short supply to identify the need, the person, a replacement, and transporting the person back to the factories where they were needed. This process would never be able to bring about sweeping and quick corrections in the labour market, but it was certainly

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<sup>601</sup> WO 111-13. Record of important events, changes, decisions, etc., by Commanding Officer, Headquarters, Woolwich. 1915-1919.

<sup>602</sup> LG C/5/7/27. Munitions of War. Notes on Action taken hitherto' by Von Donop 4 pp Typescript copy 14 April 1915.

better than nothing, and it was politically feasible, probably the most important feature for those in Whitehall.

The issue of Labour epitomizes the issue of terminology within this study, as throughout the labour crisis of early 1915 the lack of differentiation between munitions, ammunition, and artillery was striking. In one note to Lloyd George from von Donop, the issue of labour was only mentioned as slowing down ammunition production.<sup>603</sup> There was no mention of the effort of labour shortage on the production of artillery. Part of this was due to the sheer amount of manual labour required for the shells industry, as little of the process was automated, whereas the ability of the ordnance companies to surge in capacity for artillery manufacture was not as great, due to the need for very specialized equipment.

The much larger issue was simply that the size of the orders placed had never been contemplated before. The last war, the Boer War, entailed only a partial mobilization of industry as the Boers themselves did not have the industrial base to fight an industrialized war. More importantly, the Royal Navy was not engaged in combat except for a few guns that were dismounted. The last time the Royal Navy or the British Army had actually fought a first-rate enemy was 60 years before, when the Anglo-French alliance fought in the Crimea. A pre-war policy on how to mobilize

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<sup>603</sup> Ibid. 7.



industry simply did not exist for the level needed to meet the intensity of even one front let alone a multiple front war, including the North Sea.

### Drink

Alcoholism was seen as a major problem for many manufacturers. Areas around Birmingham and Glasgow seem to have been hardest hit by the lack of productivity that managers associated with long pub hours. The shipbuilding industry was claimed to have been especially heavily hit by alcohol-related absenteeism. The Defence of the Realm Act allowed the altering of license hours, which was seen as a gift to managers, especially those in shipbuilding. Interestingly, the view was not universal. The Chief Superintendent of Ordnance Factories, Sir H.F. Donaldson, believed that it was an exaggerated view. From his experiences at Woolwich, the truth was if anything the opposite. Whilst some manufacturers were quoting to the Treasury 20 to 30 per cent absenteeism, Donaldson pointed out that in just one random example, his workers had a 98.92 per cent attendance rate at Woolwich, the largest of the armaments factories.<sup>604</sup> Donaldson went as far as to post the absences that were occurring at Woolwich as not being down to alcohol, but to football

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<sup>604</sup> LG C/5/7/20 S.B. von Donop, War Office, to Chancellor. 5 April 1915.

matches, especially on Saturday afternoons. It should be noted that Arsenal Football Club was founded in Woolwich.

Donaldson also believed that a side effect of the allegations of high alcohol abuse was that they would make Britain look bad in the international press. He urged that the Government not crack down too heavily, as it would have the appearance of stigmatizing the entire workforce as being drunkards whilst Donaldson believed that the vast majority of workers were hard working, patriotic, and law abiding citizens.<sup>605</sup> The injustice of branding British workers on wartime contracts could have the opposite effect from that intended and infuriate those not guilty of absenteeism, and could even energize the enemy.

Vickers sent a request to all its factories. Results back from these managers showed that the varied experiences were probably representative of the state of British industry as a whole. The ship works at Barrow suggested severely curtailing drink, not only at the company pubs, but at all pubs within 20 miles! The manager at Sheffield had a different perspective, suggesting that 'it is difficult for them to say to what extent there would be any increase in efficiency and output' and that beer was widely integrated into the culture of several shops, including 'their Melting House, Forge Dept., Carburising Dept., and Treatment Dept., men have always been

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<sup>605</sup> Ibid.

permitted to send out for beer during working hours and these Departments have not seriously suffered in consequence.<sup>606</sup> The general theme of the Vickers managers were that as the skill of the worker increased, the desire for excessive drink went down. This made perfect sense, as those on the lowest social and skill levels had the physically hardest jobs with the least reward. Highly skilled engineers and semi-skilled workers did not have the problems that were being discussed at Whitehall.

Armstrongs also submitted a survey to the Treasury. What was most important and striking in the analysis of the work week for those at the Scotstown Newcastle plant was the hours that were being worked.

Armstrongs workers averaged 69 ¼ hours a week, trading between the night shift one week, at 12 hours a day for 7 days a week, and transferring on Saturdays to day shifts, which averaged 9 ½ hours a day. The Saturday after the night shift week was given off. It was even worse for forgemen, who worked on average 79 hours a week, as they worked through meals.<sup>607</sup>

Armstrongs employees worked 13 out of 14 days a fortnight. With this schedule, it is not surprising that almost a year into the war, absenteeism

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<sup>606</sup> LG C/5/7/26 R.H. Brade, War Office, to Mr. Hamilton. 11 April 1915. 2.

<sup>607</sup> LG C/5/7/29. Percy Girouard, War Office Armaments Output Committee, War Office, to Mr. Lloyd George. 23 April 1915.

would start to become an issue, due to alcohol or not. Industry was working all out, and the employees were taking the brunt.

### Woolwich Transfer

An example of how the transfer of power occurred was represented is that of patents. An important but overlooked piece of the transition was the transfer of patents, inventions and all other tasks that had been traditionally done by the War Office. This was supposed to transition with the initial creation, but it took much longer than Lloyd George wanted. An order in Council suspended the publication of inventions on 14 October 1915 for the sake of security, but it was not until 1916 that the entire function was transitioned over. Part of this was due to the role that officers played in the judgment of the usefulness of inventions, which the War Office was not willing to turn over until forced. In the end, by May 1916 the officers had been put at the full use of the Ministry, which had then deputed them to the Comptroller of Patents in Chancery Lane but even then it appears they were only seconded and not permanently transferred.<sup>608</sup> This lack of permanence was seen as intentional by the Assistant Under-Secretary of State at the War Office, Bertram Cubitt.

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<sup>608</sup> WO 32/9285. WAR OFFICE: General (Code 1(A)): Transfer to Ministry of Munitions responsibility for designs, specifications, etc. for testing of arms and

## New Staffs

The particular job of continuing artillery production under the Ministry of Munitions went to Eric Campbell Geddes, a former railroad executive with no experience in ordnance. Geddes was subsequently replaced two months later by Charles Ellis, who actually had experience in ordnance, as the Managing Director of John Brown & Company.<sup>609</sup> As Director-General of Ordnance Supply, Ellis would have had the requisite technical knowledge of the job of procuring ordnance, especially heavy guns.

What was most important, was that none of the senior civil staffs from the War Office contracting or financial divisions were transferred upon the creation to the Ministry of Munitions. It would not be until the end of the year that civilians that had previously run ordnance from the point of view of contracts were seconded to the department, and even then, only one principal was handed over, Mr. S Dannreuther, Esq.<sup>610</sup> All other clerks remained, and importantly, the Director of Army Contracts remained under the War Office Financial Secretary.

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ammunition Taking out of patents by officers and men and civilians employed by the War Office.

<sup>609</sup> Strachan, *The First World War*. 1079.; *The Glasgow Herald* 20 February 1937. 15.

<sup>610</sup> Army List. October 1915

## The Battle of Woolwich

One of the most difficult questions facing the cabinet was whether to keep the Royal Arsenal at Woolwich under the War Office, or to move it to the new civil Ministry of Munitions. The MGO was notified of Lloyd George's desire to transfer the Ordnance Factories on 14 August 1915, when he received a memo from the Secretary of the Ministry of Munitions that had been created two days earlier.<sup>611</sup> The transfer though was not a smooth transition, which in many regards was probably the best thing that could have happened for the British in winning the war. The Battle of Woolwich was one of the most political aspects of the industrialized war. The ability of von Donop, with the help of Lord Kitchener to fight a rear-guard action, bought time for industry to stabilize. Without this engagement, it is unknown if Britain would have been able to fight the battles in France in 1916 with the same effect.

For the transfer to take place, Lloyd George had to find a way to override the MGO and Kitchener, who were unwilling to transfer the Royal Arsenal away from War Office control. The easiest way forward was to slowly dissolve the powers of the War Office, first through the destruction of the Ordnance Board, which acted as the eyes and ears of the

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<sup>611</sup> WO 32/9282. FACTORIES: Royal Ordnance (Code 49(A)): Transfer of control of ordnance factories to Ministry of Munitions Proceedings of conference.Cover. Formerly WO 32/1433

MGO on the daily advising of ordnance issues. Lloyd George wrote the President of the Ordnance Board on 1 December 1915 that he ‘had come to the conclusion that in order to have a free hand to make the best arrangements for the discharge of the new responsibilities thus cast upon him, it was necessary to dissolve the Ordnance Board as at present constituted, with a view to such re-constitution and re-arrangement of the functions as might be found desirable’ ‘He accordingly informed the Secretary that the Ordnance Board was dissolved from the date of this letter’.<sup>612</sup>

Lloyd George had already received an Order in Council on 16 June 1915 ordering the ‘immediate transfer of the responsibility for designs, patterns, and specifications, for the testing of arms and ammunitions and for the examinations of inventions bearing on such munitions.’ The change was allowed due to the high level decision on 26 November 1915 to transfer the Board from the War Office to the Ministry of Munitions as per the Orders in Council. The Director of Artillery informed the board that the Government was transferring the Board, the Research Department, Experimental Establishment, Shoeburyness, and the Inventions Department to the Ministry of Munitions, and instructed the

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<sup>612</sup> SUPP 6/170 Annual Report of the President, Ordnance Board, for the year 1915. xvii.

board to report to the Ministry of Munitions from 29 Nov 1915.<sup>613</sup> What is important is this was done by the DofA and not the MGO. Technically, the Board reported directly to the MGO, and therefore the DofA had no authority over the Board or its transfer. As von Donop had no desire to comply with the Orders in Council, he was sidestepped by the Minister of Munitions. With this decision, Lloyd George effectively dismissed the MGO from the chain of command. The ability of Kitchener and von Donop to postpone the takeover though bought valuable time for the experts who knew what they were doing to finish mobilization as well as the delivery of almost all of the artillery on order from 1914.

Lloyd George has been quoted as stating ‘Take Kitchener’s maximum; square it, multiply that by two, and when you are in sight of that double it again for good luck.’<sup>614</sup> This rash mindset was one of the problems between him and Kitchener. For 18 pounders, this would have been 18,800,896 guns, or about one gun per three Britons at the time. The brash rhetoric from Lloyd George helped no one, and probably caused the War Office to dig in deeper to obstruct what they saw as irresponsible people taking over a task that the fate of the nation depended upon.

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<sup>613</sup> Ibid, xvii.

<sup>614</sup> Strachan. *The First World War*. 1077.



## Donaldson and Transfer

Hay Frederick Donaldson, the CSOF, was one of the few at the War Office administration who saw that the Ordnance Factories would have to be transferred. Donaldson saw this primarily as a financial issue, as the Ministry would be placing the majority of the orders in terms of value, which happened to be for shell. Donaldson's view was that the transfer was a necessary evil of the war, and that little would change, except that they would report to a different political head. He also seemed to be the originator of the idea that the CSOF should be directly under the command of the Minister of Munitions, which was a higher position than in the War Office hierarchy. This was because he saw that the Ministry was essentially borrowing the Ordnance Factories, and that they would be returned intact to the Army Council once the war was over. Donaldson in a letter to von Donop on 17 August 1915 wrote that he was worried that the transfer would take the Master General of Ordnance out of the technical loop, and possibly marginalize the position as it would no longer have direct ties to the financial decisions. Donaldson, as the long serving civil servant and engineer that he was, foresaw problems with the relative order of precedence between orders for the War Office Ministry of Munitions, and the Admiralty. Traditionally, the DNO and Director of Artillery met

to ‘discuss the relative importance of the requirements and agree as to what should take precedence.’<sup>615</sup> As Donaldson had been at the Ordnance Factories longer than anybody had been at the War Office, he remembered the issues of the Boer War and the strain placed on naval orders, which certainly influenced his decisions. He was also probably more aware than anybody else of the potential industrial bottleneck if and when the naval war intensified for Woolwich, as the only factory that had successfully relined a large naval gun in Britain.

Donaldson’s recommendation of the transfer however had a very large caveat that he would still need the advice and support of the Ordnance Board and the Royal Artillery Committee as well as the expertise of Shoeburyness and other outposts. These were all directly under the command of the MGO, and therefore, Donaldson cleverly created a way that the CSOF could be transferred, but within a constraint that did not allow the MGO to be side-lined by the move.<sup>616</sup>

Finally, the CSOF foresaw a problem occurring with any orders placed by the colonies or India, which legally would have to be placed by the War Office. In time of peace, this was not a problem as the War Office operated the Ordnance Factories, although the transfer would confuse this situation. Would a Ministry of Munitions-run Ordnance

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<sup>615</sup> LG D/17/6/20. Hay Frederick Donaldson, to M.G.O. (von Donop). 17 August 1915.

<sup>616</sup> Ibid.

Factory be able to take orders from the War Office as necessary? This question was not fully answered, but the requirements of the colonies never became a major issue, as the Royal Artillery, equipped with regular contracts would supply artillery at least in the field for colonial units. Difficulties would have arisen if great amounts of repair to coastal ordnance or other ordnance had become necessary, but due to the consolidation of fighting away from the colonies, this did not occur.<sup>617</sup>

### **Death of Kitchener**

The largest roadblock to Lloyd George's takeover of the whole of ordnance manufacture and policy had been Lord Kitchener. Kitchener played a key role in maintaining the power of von Donop as the MGO even though the Ministry of Munitions had been biting away at his power since May 1915. Lloyd George's papers comment that at every point of change, Kitchener and von Donop were there to slow down a politically motivated policy for what they believed to be the betterment of the war effort. The relationship by May 1915 was poisoned and by June 1916 there was outright war between the Ministry of Munitions and the War Office. Lloyd George's Private Secretary at the Ministry, Christopher Addison, went as far as to state about von Donop that he was 'either incompetent or

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<sup>617</sup> Ibid.

a traitor. I am inclined for the latter view'.<sup>618</sup> Von Donop had the exact same view about Lloyd George and his cronies. Nonetheless, Addison and Lloyd George had to deal with their 'traitor' as long as Kitchener had the confidence of the Prime Minister and the King.

The loss of Kitchener represented the end of top cover for the professional staff of the War Office, and the beginning of the end for intelligent procurement. Arguably the most important event in June 1916 for industry was the sinking of the *HMS Hampshire*. The cruiser sank with Lord Kitchener and his staff on 5 June off the western coast of the Scottish isle of Orkney. Included in the casualties was H.F. Donaldson, the longstanding Chief Superintendent of Ordnance Factories.

The death of Kitchener was important in the schedule of events, as it was one of three key events that occurred within a month of each other. The first was the naval Battle of Jutland, the second being the loss of *HMS Hampshire*, and the third, the preparation and start of the Battle of the Somme in France. Each of these must be viewed in context, like the ordnance industry as a whole. These individual events have never been viewed as having a key interrelationship, although each can be taken out of context without the view of impact they had on each other.

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<sup>618</sup> Strachan. *The First World War*. 1070.

## Battle of Jutland

The Battle of Jutland, 31 May–1 June 1916, was the only major naval engagement between the combined battle fleets of the Royal Navy and the Imperial German Navy. In terms of ordnance expended, the experiences of different ships were significant. The best academic analysis of this expenditure is from John Campbell's 1986 work *Jutland: An Analysis of the Fighting*. Although now 30 years old, it has still been unrivalled in the technical analysis of the battle from both sides, and is also the most widely quoted work on the subject. According to Campbell, overall, 4,480 total heavy shells were fired by British ships of 12-inch and above size. This was broken down into 1,239 15-inch shells, 42 14-inch shells, 1,533 13.5-inch shells, and 1,666 12-inch shells. Further broken down by vessel, only six British ships were outfitted with the new 15-inch guns. One, *Canada*, mounted 14-inch guns, 15 were mounted with the 13.5-inch guns, six were the short lived Mark XI 12-inch guns, and 9 were the Mark X/Mark XIII 12-inch guns which had flaws in choking. This compared to German expenditure of 2,424 12-inch shells and 1,173 11-inch shells for a total of 3,597 heavy shells.<sup>619</sup>

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<sup>619</sup> NJM Campbell. *Jutland: An Analysis of Fighting*. London. Conway Maritime Press. 1986. 346–348.

British ships had actually not fired that many shells considering the number of ships involved. 37 British capital ships fired shells at Jutland, although only 14 vessels fired over 100 rounds from a combination of their main guns in total. HMS *New Zealand* was the most heavily engaged, firing 420 12-inch rounds.<sup>620</sup> It is significant that no ship in the British fleet expended its entire magazine of rounds. As mentioned in the pre-war chapters, the life of guns was a well-documented statistic for those who had a need to know. Most importantly for the strategic industrial efforts, Jellicoe's fleet had not fired enough to require replacement of their guns. Part of this was helped by the primary guns engaged being of the new 15-inch type that had only been in service since 1914, and was an active production line, being produced in large numbers for vessels already laid down but not completed. The 13.5-inch guns were known for their long life span, which was discovered to be estimated at 450 rounds. These guns would not have had to be replaced unless the vessel had already been in heavy action, which had not really been the case. The 14-inch shells all came from one vessel, HMS *Canada*. *Canada* was originally an export built ship, but seized early in the war. The DNO stated in a 4 Feb 1915 report that once her 14-inch guns were worn out, they were to be bored out to

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<sup>620</sup> Ibid. 347.

15-inch.<sup>621</sup> Matching up the serial numbers released earlier in 1915, the DNO showed that there were no spare guns for *Canada*. As this was a one-off gun, on one ship, it would not have been a worry, especially as only 42 rounds were fired from her during the battle.<sup>622</sup>

Of the battle damage to guns caused by the enemy, one 15-inch gun from *Warspite*, and five 13.5-inch guns, two each from *Lion* and *Princess Royal* were out of action, and *Marlborough* had a premature.<sup>623</sup> No 12-inch guns were damaged during the battle. As *Warspite*, *Lion*, and *Princess Royal* were three of the four highest recipients of shells in the British fleet to survive the battle, they would have already required a substantial amount of time in the dockyards to repair and refit. *Princess Royal* was in dry dock from 13 June until 15 July 1916. *Lion* spent 5 June–8 July in repair, with a two day exception to change yards, and *Warspite* was at Rosyth under repair from 1 June through 20 July.<sup>624</sup> Therefore, each would have had plenty of time to remount guns from the reserve pool if repairs were not possible.

The 12-inch guns were another matter. As many of the vessels were by now a decade old, their expected lifespans were coming near. The *Colossus* class and its 12-inch Mark XI high velocity guns were entirely

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<sup>621</sup> SUPP 6/170. Annual report of the president. 1915. 246.

<sup>622</sup> NJM Campbell. *Jutland: An Analysis of Fighting*. 346

<sup>623</sup> Ibid. 364.

<sup>624</sup> Ibid. 335.

engaged, given with the problems of these guns, it would have been doubtful if they could have had replacements ready, as all 60 guns from the only class built were engaged. Any further engagement would have probably removed these ships from the order of battle. The Mark X 12-inch mounted ships saw 70 of the 130 total mounted in all ship classes engaged, and 16 of those guns were lost along with *Invincible* and *Indefatigable*. The reserve pool of guns would have had enough to replace the needed guns, although *Agincourt* was a one-off design, similar but not interchangeable with the others of her size. *Agincourt* fired 144 rounds from her 14 guns during the battle.<sup>625</sup> The other ships should have not been a worry. Technologically, they were obsolescent as first class warships, with the newer vessels being faster, having heavier broadsides, and with the introduction of oil fired ships with the *Queen Elizabeth* class in 1914, the older coal fired ships had an increasing list of disadvantages. In addition, their guns had a much shorter lifespan, as has been discussed in previous chapters relative to the newer guns. It probably would not have been worth relining these barrels at the expense of more pressing needs unless the German navy had won Jutland or somehow the newer vessels showed a serious design flaw, which was not the case.

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<sup>625</sup> Ibid. 346.



## **Battle of the Somme**

In addition to naval engagements on the high seas, June 1916 was a time of high preparation for the Somme, which was to be the largest artillery bombardment ever conducted to that date by the British Army. Two years of contracts and gun building had finally fielded a British Army that was over 50 divisions. The reserve for some guns was quite thin, and even at the rate of firing in the spring of 1915 of 50 rounds a day, an 18-pr would wear out in 120 days. Although they were designed to be easily relined, there were 3,500 guns in the field with British divisions. The 6-inch gun situation was even worse. The life by the Somme of these guns was 166 days, although it took five whole months to reline them, reproof, and get them back to France, and became one of the largest headaches of 1916. This does not even mention over 1,000 4.5-inch howitzers, over 800 60-pr guns, and a host of heavy howitzers and guns at Army level, which were the only weapons capable of reaching enemy supply lines.

## **Increases in the BEF**

The War Office had calculated that the British Army could outfit 50 divisions in the field by the end of April 1916. This analysis was not completed until 20 July 1915, but it took into account the might and real

mobilization pace of British industry as well as the needs of the commanders in the field. It was not until 21 August 1915 that David Lloyd George formally put down the need for 100 divisions to his procurement staff. The need was actually for 80 divisions, although with a 25% wear factor, the 100 division requirement for guns was born. The 80 division number was not explained in the memo, except for that it would pertain to men and munitions, whilst equipment was for 100 divisions.<sup>626</sup>

A memo that appears to have been written by MGO 6 November 1915 states that ‘The advent of the New Ministry of Munitions has not as far as I can tell, been the cause of the increase in the supply of gun or rifle ammunition to the armies in the field except so far as the labour conditions have been improved by the action of the Munitions Act, although it cannot be denied that the enormous staff of the Ministry have helped indirectly to increase the output. The American orders have been chiefly instrumental in saving the situation and these orders were placed in October and November 1914.’<sup>627</sup> The same letter mentions that by November, no Ministry of Munitions orders for essentially anything had arrived, including filled shells, fuzes, or gains.

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<sup>626</sup> WO 161/23. Statement of ammunition. Appendix III Possession at Outbreak of War; also numbers since received and numbers still due. 2 June 1915.

<sup>627</sup> Ibid.

## Guns from the Commonwealth and India

In addition, this was supplemented by June 2<sup>nd</sup> of 1915. 13-prs had been increased by 47 from India, and 12 from Canada; 18-prs by 240 from India, 84 from Canada, 36 from Australia, 12 from New Zealand, and 511 manufactured since the war. 12 4.5-inch howitzers were brought from India, four from New Zealand, and 117 had been manufactured.<sup>16</sup> 9.2-inch howitzers had been manufactured. No additional other guns or howitzers had been made or brought from the Dominions.<sup>628</sup>

A note from 21 August 1915 states that several guns were being transferred from the RN to the British Army. Included in these was one 12-inch gun on railway mountings which was to be delivered in the middle of September as well as eight 6-inch guns with 30-degree carriages. The report also showed that for the 18-prs in particular, 3,073 were still on order, and, with full deliveries, 4,580 would be completed, although 583 is also pencilled into the text.<sup>629</sup>

## Industrial Decisions

Between July and December of 1915, industry was finally in full swing, as the contracts placed in October 1914 were finally reaching full

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<sup>628</sup> Ibid. Appendix III Possession at Outbreak of War; also numbers since received and numbers still due. 2 June 1915.

<sup>629</sup> WO 161/23. Letter from Rear Admiral Morgan Singer, 21 August 1915.

output. In the last six months of the year 1,904 18-prs were produced, 416 4.5-inch howitzers, 104 60-prs, four 6-inch howitzers, 39 8-inch howitzers, 14 9.2-inch Mark I howitzers, and even four of the new Mark II 9.2-inch howitzers, and one very heavy 15-inch howitzer.<sup>630</sup>

In addition to the deliveries to December 1915 listed above, between January and June 1916, 1,020 18-prs were delivered, 682 4.5-inch howitzers, 293 60-prs, 184 6-inch howitzers, 18 8-inch Howitzers, an astounding 76 9.2-inch howitzers, and 16 12-inch howitzers of all types, as well as 11 15-inch howitzers.

Vickers requested financial assistance in October 1915 for outlay of plant to produce new ‘guns’, which through the records appears to mean the 6-inch howitzers they were just starting to complete. The subsequent Ministry of Munitions conversations show that even five months into power, the Ministry still did not have a grasp of the gun-making industry. The Ministry approved a Vickers proposal to extend their plants at a cost of £800,000. This included £134,481 at Sheffield, which must be assumed to be the River Don plant. The oddity was that this loan was approved by both the Ministry and the Treasury knowing full well that it was based without estimates, and even included 25% for contingency. It is unknown what the expenditure was for, as by October 1915, production was at full

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<sup>630</sup> MUN 5/179. Minute on shortage of 4 5’ and 9 2’ high explosive shell.

capacity, and in subsequent months, 18-pr orders were winding down, allowing for capacity to be used for the new howitzers. In addition, it was decided to go against the advice of creating a proper pricing estimate based upon the battery of the howitzers already produced by the time the request was made.<sup>631</sup> Overall, it showed a lack of understanding of business in general and at worst a reckless disregard for government spending on the other hand. With hindsight it was an even worse deal, as the debt was essentially cancelled in 1919 by the Treasury and Inland Revenue as part of a scheme to settle tax issues with the firm.<sup>632</sup>

In comparison, the RGF and RCF combined received, to the end of December 1917, a total of £618,920 to extend their works for their wartime effort.<sup>633</sup>

### Repair Work

Repair work was considered the key element of the Royal Factories according to the 1907 Murray Report, as mentioned in Chapter Two. This domain was according to the report the primary purpose of the arsenals after the mobilization of industry sometime after the first six months following the outbreak of war. There are many reports in the Board of

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<sup>631</sup> MUN 5/105/400/54.

<sup>632</sup> T 1/12290. Papers registered in 1919.

<sup>633</sup> T 1/12275. Papers registered in 1919.

Ordnance papers, SUPP 6 at Kew, authorizing maintenance work, although these are contradicted by a set of papers held in the Ministry of Munitions reports that show every order for repair and deviation from pattern. The repair work conducted by the trade was exclusively for the purpose of fixing errors in manufacturing of the particular manufacturers. This shows that no repairs to battle damaged or worn guns were conducted by the trade. There were many errors as the war increased, and most of these came from items that would have either a) were caused by the speed of wartime output or b) would have never been granted a waiver for acceptance in peacetime. Incompetent mistakes such as mis-drilling breech screws were somewhat common, for both Land Service and Naval Service contracts.<sup>634</sup> Much of this would have probably been due to the workforce quality drop. The reports do not give the dates of error, although the contracts given are mainly in the early 1914 and 1915 contract deliveries with delivery dates in the summer of 1915. If indeed the new workforce was still in training essentially, these stupid mistakes would have both delayed delivery and increased work for not only the relatively rare experienced workers to fix, but also for the inspectors.

Inspectors were still a problem no matter the agency they reported to. By December 1916, there were still only about 100 certified inspectors

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<sup>634</sup> MUN 7/463. Lists of variations from approved gun designs.

under the Woolwich Inspection Department. When Gen. Minchin took over the inspection services, much of his initial work was to increase the inspectors, although by this time, the vast majority would have been required for munitions much more than ordnance.<sup>635</sup> This staff though, had by August 1916 increased their amount of throughput of guns alone by 1400 per cent since 1914.<sup>636</sup> It might have been said best in an August 1916 memo from the Inspection Department that stated ‘Guns, Shells, Fuzes, and all other Munitions to be of value must not only be dangerous to the enemy, but safe to the troops using them’<sup>637</sup>

In addition, 100 18-prs had been repaired in the last half of 1915. This appears to be under-reported, considering the wear rate, which should have required a repair bill in excess of 1,000 field guns by this point in the war.<sup>638</sup>

### **Foreign Suppliers**

Increasingly, the Ministry was tasked with managing a world-wide network of suppliers. With European capacity completely filled since the outbreak of hostilities, European governments were forced to look elsewhere. This was most pronounced in the world’s largest steelmaker,

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<sup>635</sup> MUN 5/122/900/2. Inspection.

<sup>636</sup> MUN 5/122/900/3 Inspection.

<sup>637</sup> Ibid.

<sup>638</sup> MUN 5/179. Minute on shortage of 4 5' and 9 2' high explosive shell.

the United States. Although a good amount has been written on the work of the committees sent from the Allies to the US in the early months of the war, much of it is not relevant to the procurement of artillery. Many of the orders for guns were ordered directly between the War Office and Charles Schwab, the director of Bethlehem Steel, in Bethlehem, Pennsylvania. There is little mention of artillery in the papers between the British Government and the American representative of Britain, and later the Allies as a whole: J.P. Morgan & Co. The timing of orders was quite important. As they were placed between August and November of 1914, the capacity of the Bethlehem plant was ring-fenced from a very early time. As well, this would start the delivery clock, which the traditional customer of Bethlehem, the United States Army Ordnance Corps, considered would take 18 months. Therefore, no American orders had a conceivable delivery date until sometime into 1916, and after shipping, could probably not be considered available for front-line use until the summer offensive in 1916.

This worldwide capacity was a greater issue for some Allies than others. The Russian government placed massive orders in the US for all sorts of warlike goods, including over a million rifles, and more relevant,



65 artillery pieces.<sup>639</sup> The British government eventually acted as the intermediary between the American manufacturers and the Russians, bankrolling many of the orders. The British also took a great deal of political criticism from Russians over the Russian supply issues, which was one reason why Kitchener was on a diplomatic mission in June 1916. Procuring guns and munitions was now becoming a major issue in keeping the political alliance together.

### Inspection

The one governmental failure in the war was that of the inspection department. Inspection of arms both at government facilities and at Trade plants was by its nature heavily dependent on former servicemen. A report published in 1906 showed that roughly 400 of the 1200 men employed by the government at Woolwich were prior servicemen. Over 10% of those were reservists who could be called up at any time. This high proportion gave invaluable operational experience to inspectors to fall back on and influence their decisions, but it also made them vulnerable to being called back in time of conflict, just like they had been in 1899-1902. The

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<sup>639</sup> MUN 7/148 Miscellaneous papers of Sir Philip Hanson, Director-General of Munitions Contracts and Assistant Secretary, American Branch, mainly concerning munitions supplies to Russia.

department was, by the nature of its work, in a critical area for personnel drawdown just as it needed the opposite.<sup>640</sup>

### **Deliveries under the Ministry**

The Ministry in the realities of operations was unable to deliver contracts of ordnance any faster than the previous War Office. In a list for ordnance ready since the Ministry took over until the end of March 1916, 6-inch howitzers were being delivered to 206 versus 280 as scheduled, 82 8-inch howitzers versus the scheduled 107, 66 9.2-inch howitzers versus 75 planned, and 28 12-inch howitzers versus the 40 scheduled. The only thing that the Ministry had found to be delivering ahead of schedule was the 6-inch gun, for which there had been 36 versus a scheduled 24, although eight of the 12 had come from an Egypt order that had been received from the Admiralty, and therefore not due to the Ministry for success.<sup>641</sup> In reality, the Ministry came late to the game. The 18-pr peaked in October 1915 with 418 guns delivered that month alone. A year later, it was 45.

Field Marshall W.R Robertson sent a note to Lloyd George on 21 January 1916 that gave the availability of munitions to France by 1 May

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<sup>640</sup> WO 33/2960. Report of the Committee appointed to consider methods of inspection and delivery of naval ordnance and naval ordnance stores.

<sup>641</sup> WO 161/23. Note 28/12/15 MGO to AG, CIGS, QMG.

1916, and the 18-prs were allotted almost 2,900 rounds per gun, or enough to halfway wear out a gun, although these numbers were granted by allowing just five rounds a day, one tenth the amount Field Marshall John French wanted in the spring of 1915. In addition, the inability to produce both guns and munitions for the 4.5-inch howitzers was becoming a grave problem, considering if the Russian order was fulfilled, just 145 rounds per gun would be left, again with a meagre 5 rounds per day.<sup>642</sup>

The spring of 1915 was the most critical period of the war for British munitions. The shortages of labour caused delays and quality issues that forced the War Office to transfer work of ordnance to the new Ministry of Munitions. Although the War Office delayed the transfer as much as possible, the eventual transfer of ordnance seemed inevitable. By the time the Battle of the Somme entered its final stages in late 1916, British ordnance issues had become one of attrition and replacement of used guns.

### Army Needs

The needs of the British Army were defined by General Sir Douglas Haig in a letter to the War Office dated 24 June 1916. He outlined three layers of artillery, the divisional level, the corps level, and the army level. A

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<sup>642</sup> WO 161/23. letter from WR Robertson to David Lloyd George, 21 Jan 1916.

corps contained two divisions, and an army contained three corps. The divisional level would require 48 18-prs and 16 4.5-inch howitzers. The corps level would require 24 60-prs, 60 6-inch howitzers (a weapon Haig considered obsolescent by this time), eight 6-inch guns, and 24 heavy howitzers, for a total of 116 per corps. Army howitzers included all railway mountings and the 9.2-inch and over guns and howitzers, and were to include 16 howitzers of which 50% were tractor drawn, and four guns. Haig's statement in the same letter stated that 'it is not practicable to eliminate at present any existing types, and that circumstances governing manufacture of guns, howitzers, and ammunition will probably necessitate the present variety of types remaining in use for the war.'<sup>643</sup> This understanding of manufacturing limitations on military strategy seems to have set Haig apart from Gen. French, his predecessor. The 6-inch guns were provided by this point through the dismemberment of coastal batteries and their guns sent to be modified. By 30 September, 1916 35 guns had been transferred, along with enough cradles.<sup>644</sup>

The Army's requirement by the 7th of July 1916 was for 72 divisions comprising 24 Corps, but just as importantly, with a reserve of 25%<sup>645</sup> Even

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<sup>643</sup> MUN 7/440. Letter 24 June 1916 From Douglas Haig to Secretary, War Office

<sup>644</sup> MUN 7/440. 57/3/5111.

<sup>645</sup> MUN 7/440. letter from W. T. Layton to D.D.G. late 7/7/1916.

without an additional order, the initial orders in 1914 would have covered this amount for field artillery, with a slight reserve.

### Long Range Guns

Probably the largest new need during this time period was a requirement for modern long range guns. GHQ in France on 24 June 1916 sent a letter to the Director of Artillery for the operational need for a 6-inch gun and a 9.2-inch gun for use in France. The description given by the Minister is indicative of the new way in which the Ministry, and Lloyd George in particular, operated. His response stated that ‘the interpretation that I have put on the respective responsibilities of the two Departments is that the War Office are entitled to ask for any number of weapons of approved types that they may require, but that when new types are involved they should confine themselves to specifying the general conditions that the design should fulfill.’<sup>646</sup> The 9.2-inch guns consisted of four reserve 9.2-inch Mark X guns which were to have new guns built to replace the losses in reserves. As the likelihood of these guns being needed as reserve guns by either the Royal Navy or the Coastal Artillery would have been slim, this probably was a good decision.<sup>647</sup> These 52,000 pound guns were turned

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<sup>646</sup> Ibid.

<sup>647</sup> MUN 7/440. Letter, Edmund Phipps to Secretary, War Office. 24 August 1916.

over to Vickers on contract 94/G/2791 to be placed on railway carriages sometime before 22 August 1916. The replacement guns were to be made out of four Italian tubes, for an unknown ship, that Vickers had lying in the factory. These were made to represent the Mark X, but were not interchangeable, and seemed to be made for replacement railway carriages. Therefore, the use of these reserve guns indeed removed four guns from the total reserve pool as their replacements could not be used for the purpose of the original guns and were to be renamed Mark XIV and issued serial numbers 453–456 for the convenience of the Ministry.<sup>648</sup>

The slow realization by the Ministry that they were unable to provide much to the armies in the field without simply going to Vickers and accepting their design wholeheartedly and without delay demonstrated emphatically that the Ministry having design responsibilities was simply not suitable for purpose. The discussion was played out in letters between Lloyd George, Edwin Montagu, who took over as Minister after the elevation of Lloyd George in December 1916 to Prime Minister, and the Stanley von Donop, the Master General of Ordnance as the War Office representative in the letters.

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<sup>648</sup> MUN 7/440. Memo GC/169.

## 6-Inch Guns

The 6-inch guns, which were based upon a lighter version of the Mark VII guns, also in 35 calibre, had a slightly longer range of 18,000 versus 17,400 yards (on a field carriage) and were light enough to use in the field. The rehashed Vickers design seems to have been pulled off the shelf of many an R&D project done before the war, and placed on the already proven 8-inch howitzer carriage. What is of importance for the sake of this thesis is that manufacturing did not appear to take any role in the placing of these orders. This might have been because almost all orders that were placed for the new armies had been completed by July 1916. With guns in the field, there was less risk politically for any failure of an army-level weapon which at numbers of only 50 were not enough to be of any great importance if they failed. What also should be of significance is that these documents were classified until they were requested to be declassified in May 1942 to make room for more documents in Whitehall. This classification for so long was not due to any technical data in the sake of national security, for the gun design was not included in the papers, but the political discussions between a senior Minister and the Prime Minister could be seen as controversial. This airing of dirty laundry would have

been the only reason that this was classified and not included in the initial official records as well as the correspondence placed in the records.<sup>649</sup>

The orders for increased 6-inch guns were not placed until November 1916, and would be one of the last major orders given during the war. The Ministry of Munitions, with permission of the Army Council, placed orders for 50 6-inch Mark VII guns for delivery between June and November 1917 and 270 6-inch 35 calibre Mark XIX guns, for delivery between August and the end of 1917. This order was to be considered below the priority of previous orders, and would not be allowed to interfere with howitzers, now the object of repair work, which meant that no orders were to go to the Royal Gun Factory.<sup>650</sup> As Haig's request and need was for 192 guns in total, a reserve of nearly 50% showed both the wear-out rate for guns in theatre as well as an ordering style of the Ministry to order more rather than less if given the choice.

### **Ministry of Munitions Bureaucracy**

Lloyd George would remain the Minister of Munitions until 9 July 1916. He had taken over the position of Secretary of State for War on 6 June 1916, the day after Lord Kitchener was lost on the *Hampshire*. His

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<sup>649</sup> Ibid.

<sup>650</sup> MUN 7/440. letter B.B. Cubitt to Secretary, Ministry of Munitions. 2 Nov 1916.



successor was Edwin Montagu, a former Under-Secretary of State for India before the war who had been the Financial Secretary to the Treasury under Lloyd George in the opening months of the conflict. The transition was not a significant one, as it appears not to have changed things in regard to artillery production. Montagu took over with the same style of anti-War Office rhetoric that Lloyd George had perfected.

Lloyd George and others had always been cynical about the abilities of the War Office staffs. By 1916 the animosity had reached fever pitch, especially after the loss of Kitchener. In a note dated the same day as Kitchener's death, 5 June 1916, Lloyd George wrote to Edwin Montagu that the fault for any dud shells lay in the hands of von Donop. Lloyd George took the distinct view of General Du Cane being the honest successor whilst von Donop was still being obstructionist, although documents in the same file showed that the MGO warned him of the problem over a year before, and the Ministry of Munitions had failed to act. It would have been very difficult for Lloyd George to argue that any material failures a year into the transformation were still the fault of the War Office, although he continued to.<sup>651</sup>

Von Donop would remain as the Master General of Ordnance until 6 December 1916, when he resigned and retired from active duty.

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<sup>651</sup> LG D/17/16/4. Lloyd George, to Montagu. 5 June 1916.

## The Ordnance Committee

By January 1917, the wartime Ordnance Committee was in trouble. The group did not have the skill and long term experience to oversee the production of guns, although they still were able to effectively procure shells in extraordinary numbers. In January 1917 the Committee met and decided to ease the requirements for nickel steel to the specification for nickel chrome steel, which had been an inferior specification for a decade since it had been baselined upon the old carbon steel specification. This was against the policies of the pre-war Board and of the designs since 1907 that required the new steel. As well, it showed that by 1917, the technical government bureaucrats were almost wholly pushed out of power or removed of all influence and independent thought. The Government had lost power as compared to the lobbying of the arms firms. The most visible sign of this was that the 18-pr tolerances were extended from .007 to .010 inches.<sup>652</sup> These tolerances would have been unacceptable in peacetime, and were unacceptable to all of the initial contracts written by the experts at the War Office as they had been shown to be detrimental to ordnance and a basis for cracking.

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<sup>652</sup> SUPP 6/266. Annual reports of proceedings 1917. 976-977.

The worst part of these decisions was that they made little sense. The Government had already acquired enough guns to outfit the entire British Army. The only guns that were still being actively produced were the 4.5-inch howitzers and the new heavy and very heavy howitzers that were replacing older models already in the field. There was no reason to introduce a weakening of specifications as British industry had already proven it could outfit the majority of the British Army domestically with artillery in a true crisis with the peacetime specifications. By 1917 the industrial base had matured to a wartime footing and the massive investment in plant was now available.

The only other possible understanding was that this was aimed at the export market, although the flagging Russians were the only possible customer in January 1917, and no records exist that the Russians were even remotely interested in the 18-prs as they had no capacity for supply of their ammunition.

### **State of Contracts in April 1917**

By the entry of the Americans into the war, most contracts for artillery had been fulfilled. What was still on order appears to be primarily for the Allied armies elsewhere. For example, \$538,500 was still owed by the Russian Government for gun orders in the United States. This was for

an order placed at Midvale Steel by Morgans on behalf of the Ministry of Munitions. With the last Russian gun rolling off the line on 30 November, 1917, the orders for Allied artillery equipment was essentially completed, and American factory capacity could be turned over to the American Governmental orders.<sup>653</sup>

### **Relining Guns**

The relining of 6-inch guns had taken a key role in the industrial output by November 1916. It took five months from the time guns were condemned until they were back in service after relining and proof. With the average life being just 166 days, this led the Ministry to have a reserve of 100% of 6-inch guns. This extreme case meant that Woolwich would have to rebuild on average over one gun a day to keep up with the demands from France.<sup>654</sup>

### **Subsequent Contracts**

On the business side though, the Ministry was in reality not actually ordering that much. In the contracts book from 9 December 1916–14 April 1917, only a handful of relined barrels were ordered, and certainly

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<sup>653</sup> T 1/12267. Papers registered in 1918.

<sup>654</sup> MUN 7/440 D.M.R.S./404.H 25 November 1916.

not enough to keep up with demand, and only then for 18-prs and 6-inch guns. In addition, only one order for guns was placed, for the almost 20 year old 6-inch Mark VII.<sup>655</sup> The Ministry was not demonstrating any thought about stockpiling, or using the industrial base that had been so important to mobilize for shells a year earlier. It might also though show that the furnaces at Woolwich were producing a much larger percentage of the steel necessary for relining from their own furnaces instead of the traditional route of outsourcing these to the second tier of suppliers such as Darlington or Firth.

### **Final Deliveries**

The final amounts for new deliveries through the end of June 1917 are astounding. 5,025 18-prs, 1,789 4.5-inch guns, 989 60-prs, 45 6-inch guns, 1,289 6-inch howitzers, 417 8-inch howitzers, 276 9.2-inch howitzers, 68 12-inch howitzers of all types, and 12 15-inch howitzers.<sup>656</sup>

In addition, at least 845 18-prs, 101 4.5-inch howitzers, 240 60-prs, 66 6-inch guns 50 6-inch howitzers, 32 8-inch howitzers, 33 9.2-inch howitzers, and 2 12-inch howitzers were repaired in the war to 30 June

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<sup>655</sup> MUN 2/34. Contracts.

<sup>656</sup> MUN 5/179. Minute on shortage of 4 5' and 9 2' high explosive shell.

1917. In most cases, in three years of war, more guns had been repaired than had been in the entire arsenal in August 1914.<sup>657</sup>

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<sup>657</sup> Ibid.

## **CHAPTER ELEVEN: CONCLUSION**

Although this is not a comparative study, it should be noted that Germany consistently during the war replaced its drive band designs on shells from copper to soft iron.<sup>658</sup> This meant that the rifling in German guns would have worn out much more rapidly than their French and British counterparts. This is important as it might have influenced the ability of the German fleet to rearm their dreadnoughts as their industrial might by 1916 was being strangled by the blockade which was having follow-on effects. As copper was not able to be imported, substitutions were being used, which caused increased wear, decreased efficiency, and forced industrial decisions as to the priorities for gun makers.

On the other side, Britain was never forced to make these sorts of decisions. The Royal Navy was able to keep the sea lanes open enough to get all the supplies needed for the ordnance industry. Copper was never in such short supply that designs were curtailed, and the relaxation of specifications that occurred in early 1917 does not appear to have any direct cause due to raw materials. Much of this could be credited with Canadian and American supplies, as well as a direct sea route to the South American copper fields, but it cannot be understated how important being

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<sup>658</sup> Hew Strachan. *The First World War Vol. 1*. 1028.

able to use weapons as designed was. It allowed much more accurate artillery over a longer life which put shells where they were aimed more of the time. It also meant that the repair work at Woolwich was much less than it could have been. The best example of how this could have been was Krupp, which ‘mended more guns than it made new ones’ and also had excessive amounts of prematures, 2,300 field guns and 900 howitzers in 1915 alone.<sup>659</sup>

This seems to vindicate the British design and business policies before and during the initial months of the war. British guns were more effective against the enemy than their own, which could not be said for their German counterparts. In a succinct representation, the British comparison to their German counterparts shows that British industrial policy was indeed efficient and effective, as it took into account all elements: design, capability, capacity, industrial culture, probable environments for use, efficient tactics, intelligent tradeoffs, probable restriction of raw materials in wartime, and most importantly, the safety of crews which allowed for a culture of trust between gunners and their equipment. The policies created in the two decades before the outbreak of war in 1914 took into effect lessons learned from conflict abroad, with increased naval reserves and a need for shared service wartime capacity,

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<sup>659</sup> Ibid. 1037.



paired with an understanding by both services that the most effective gun might not be the one that could fire with the most speed. The ability of the guns to fire more rounds in an efficient life, paired with an increased research and design over a long period controlled primarily by the Government, allowed for efficient learning of lessons that could be incorporated into designs for new guns.

The system of 'business as usual' worked. The War Office was able to write contracts early in the war for amounts well in excess of the probable needs, even though even these numbers proved to be below the political needs of the war as was seen in May 1915. Industry was able to deliver on contracts, even if they were often late. Importantly though, they arrived in time to British troops in the field and were never without guns, which is more than could be said for shells, rifles, and other ordnance, and for that matter, non-warlike stores. This had as much to do with the size of expenditure on those items and industry as a whole as with the actions of the War Office staffs.

The Admiralty policies set before the war, just after the experiences in South Africa, also showed that they were well thought out and managed. The Royal Navy was never knowingly pushed off the seas due to guns failing or the inability to mount reserve guns. The realization of weakness in the 12-inch battleship guns in particular was mitigated in a way that did

not affect the supremacy of the Royal Navy in maintaining the sea-lanes for trade. This in itself allowed for much of the strategy utilized by the Allies on all fronts of the war. If Britain had gone to war with the guns of 1909, there might not have been the same conclusion. Although the long lead time of naval guns meant they had a negligible effect on the overall industry of artillery tubes, the Trade did not have to make the hard decisions as to what contracts to complete first, as had been the case in the Boer War.

Arguably the most important element, however, in the success of British policy was people. Britain had a culture of scientific promotion that should not be forgotten. Ordnance in particular was managed by officers who had experience from combat or years at sea. The Ordnance Committee/Board had the independence to conduct experiments without political or service meddling in the results. These experiments in turn had a direct influence on how to make the next generation of ordnance. The financial and audit staff of the War Office and the Admiralty had independence in conducting accurate and uninfluenced reports which were shared and learned from between the political and civil staff levels of government.

British policy between 1900 and 1914 placed the armed forces of Great Britain on a level that was sufficient for the needs of the service. It achieved both of the goals mentioned in the Second Chapter. First,

industry must be able to produce the material needed for the ordinary operations of a peace-time military at a cost that is reasonable to the taxpayer. Second, industry must be able to produce the material needed for the extra-ordinary operations of war at a rate that is reasonable to the user, in this case the Royal Navy and the British Army. Britain was able to achieve both of these outcomes. The secret was in taking on problems through the perspective of British needs as a whole, through joint dialogue, planning, design, and procurement. This system, although dented several times between 1900 and 1914, enabled both forces to fully utilize the capacity of the industry available as well as have the right equipment at the right time for the right price. In procurement, that is the ultimate goal. In that regard, British industrial policy concerning the ordnance industry between 1900 and 1917 was a success.

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- WO 32/7064 **CIVIL STAFFS (OUTSTATIONS): General (Code 47(A)):** Proposed substitution of full market rates of wages for present rate plus privileges.
- WO 32/8965 **REGIMENTAL DRESS AND BADGES: Officers (Code 43(M)):** Reports on new pattern Staff forage cap.
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- WO 32/9282 **FACTORIES: Royal Ordnance (Code 49(A)):** Transfer of control of ordnance factories to Ministry of Munitions Proceedings of conference.
- WO 32/9285 **WAR OFFICE: General (Code 1(A)):** Transfer to Ministry of Munitions responsibility for designs, specifications, etc. for testing of arms and ammunition Taking out of patents by officers and men and civilians employed by the War Office.
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WO 79/74 Correspondence and papers arising mainly from the controversy concerning the supply of munitions for the Army and the creation of a separate Ministry for this purpose. Also includes some papers relating to the rejection by the War Office in 1919 of von Donop's request to publish his notes.

WO 79/75 Correspondence and papers arising mainly from the controversy concerning the supply of munitions for the Army and the creation of a separate Ministry for this purpose. Also includes some papers relating to the rejection by the War Office in 1919 of von Donop's request to publish his notes.: with particular reference to the publication of Lloyd George's War Memoirs in 1933.

WO 79/76 Extracts from Hansard, 1915-1916, concerning the supply of munitions with accompanying notes by von Donop.

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